

J. A. Fleming

AN
INTRODUCTION
TO
PHYSIOLOGY,
BEING
A Course of Lectures
UPON
The most important PARTS
OF THE
ANIMAL OECONOMY:

In which the Nature and Seat of many Diseases *are* pointed out, and explained; their curative Indications settled; and the necessary Connexion between regular Practice, and a Knowledge of the Structure and Uses of the Parts is evinced, and illustrated.

By MALCOLM FLEMING, M.D.

Quantacunque fuerint aliorum conamina, semper existimavi mihi vitalis auræ usum frustra datum fore, nisi et ipse, in hoc studio versatus, symbolum aliquod, utcunque exiguum, in commune Medicinæ Ærarium contribuerem.

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INTRODUCTION

PPR YEST OF OGY

A COURSE OF LECTURES



THOUGH many of the principles
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P R E F A C E.

ALTHOUGH many excellent treatises on the animal œconomy have been published of late years; yet a compendious body thereof, comprised in one volume, of a moderate size and price; but withal so comprehensive as to serve, in a competent measure, for a foundation, in it's kind, of a rational and regular practice, to readers previously instructed in anatomy, seemed to be still wanting in our language; especially for the use of beginners; and above all for those, whose lot it may be to practise the healing art, at home or abroad; by sea or by land; without having had the benefit of an university education; and with but a scanty stock of erudition. For such chiefly the following volume is calculated. But it hath been endeavoured, also, to render it not altogether useless to the more learned and knowing. To them it may supply the place of a remembrancer, or recapitulation of what they have been taught before, in a fuller and more diffused manner.

It's groundwork was a course of private lectures I read in London in the year 1751, which, since my removal into the country, I have corrected and very much enlarged.

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In the anatomical part I have followed those writers of the first rank, who began to flourish in this present century; and WINSLOW chiefly; by whose clear, just and accurate descriptions, true anatomy hath been so much improved. Amongst the more ancient, VESALIUS, EUSTACHIUS, RHUYSCH, and a few more, have not been neglected. With respect to the uses of the parts; I have had all along in my eye BOERHAAVE's Physiology, with the corrections and improvements of HALLER. Nor have I omitted to consult numberless other treatises, of the best note, on their respective subjects.

It is hoped that those readers, for whose benefit this manual is principally intended, I mean beginners and the unlearned, will find their account in the mixture of Pathological matters with the Physiology. It hath a tendency to render their ideas of the nature and seats of diseases more clear and comprehensive; and to imprint the rational indications of cure more deeply and indelibly in their minds: and, likewise, to evince the close connexion between the theoretic and practical parts of medicine. And I may justify myself in choosing this way of conveying medical instruction by the example of the great RIOLANUS, in his Enchiridion: and other celebrated writers since his time.

In a work of this kind, which from its nature is compilation, discoveries will not be required by the equitable reader. But it is hoped that some things, both new and useful, will be found amidst the heap of what others have taught before. At least I can with great truth

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truth declare, that in this volume I have started Hints, which to myself appear so, without being beholden for them, either to books, conversation, or correspondence.

As it was impossible to comprehend, within the bounds prescribed, an equally diffused account of every part of the animal economy I have treated of, without rendering the whole either too poor and defective as a system; or too dry and obscure through conciseness, as an introduction for the use of beginners, I have been fullest on those heads, which are most important and fundamental, and bear the nearest reference to rational practice; and, therefore, have been obliged to treat more briefly of the rest. To atone for which want of uniformity in the execution, I have now and then referred, for farther satisfaction, to the best authors on the subjects in question, specifying their names, and sometimes pointing out wherein they are faulty or defective. Thus the student may have it in his power, not only to be more fully instructed in what he wants to know; but besides, to rectify such mistakes, as may have crept into my pages / ~~which, however, it is hoped, will not be found often very material; much less dangerous,~~

If the language should be censured as loose and negligent, the best excuse I can make for myself is, that the same correctness and elegance of stile is not required in arts and sciences, as in the Belles Lettres: I might add in lectures as in set treatises; the former being *Sermoni propiores*, more nearly approaching to com-

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mon conversation; where an easy, familiar perspicuity is chiefly commendable. If this plea be deemed insufficient, I have only one more to offer, to wit, that having, in my leisure hours, and intervals of practice, already been at no small pains to dress them in the garb they now wear; I was unwilling too long to retard their publication; lest by heaping delays upon delays, it should be put off *ad Calendas Græcas*: a fate, which, no doubt, hath attended many works, that might have been well received, and proved useful, had not the ambitious delicacy of their authors restrained them from appearing in public.



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CORRECTIONS and ADDITIONS.

Page 62. line 9. from the bottom, for *palpebraricus*, read *palpebrarum*. p. 69. l. 18. b. for *any degree of life*, read *that small degree of life*. p. 77. in place of the paragraph beginning, *At the same time, &c.* and the next paragraph, read as follows:

The velocity of the blood flowing through the lungs, and the friction of it's globules against the smallest vessels there, must be very great for this reason, to wit, that while a certain quantity of blood, suppose three ounces, is supplied from the aorta and venous system to be poured by the right sinus and auricle into the right ventricle, an equal quantity must pass in the same space of time through the system of narrow pulmonary vessels. But it is by the friction of the red globules of blood against the walls of the vessels, through which they move, that animal heat is principally effected; and, therefore, the heat of the blood, while passing through the lungs, would be excessive, were it not that the air, we breath, is always cooler by many degrees of the thermometer, than the blood of a living animal ever is; and by being drawn into the vesicles, of the lungs, upon which the smallest divisions of the pulmonary run, tempers the heat, which would otherwise arise from the great friction there; and restrains it from becoming too intense.

This is so very certain, that no animal, furnished with lungs, can live many minutes in air, that is not considerably colder than it's own blood. See BOERHAAVE's experiments on animals shut up, in an oven heated to a certain degree; in his Theory of Chemistry; Experiment XX. Corollary 16. on fire.

Page 97. line 5. from the top, for *nature*, read *stature*. p. 102. l. 14. from the bottom, for *adunion*, read *adunation*. p. 106. l. 5. t. for *gramineous*, read *graminivorous*. p. 124. l. 17. b. for RUGER, read RIEGER. p. 125. l. 4. t. for *by*, read *ty*. p. 139. l. 9. b. for *vesicles*, read *tubercles*. p. 158. last line, read *I do not find*. p. 169. l. 8. t. for *light*, read *tight*. p. 190. l. 11. b. for *to interpose*, read *to be interposed*. p. 235. l. 5. t. for *to the left*, read *to the rest*. p. 253. penult. line for *inhaling*, read *influx into the rectum*. p. 256. l. 5. b. for *barred*, read *bared*. p. 259. l. 16. b. for *convex*, read *concave*. p. 262. for *adulterated*, read *edulcorated*. p. 263. l. 18. b. for *fence*, read *series*. p. 320. l. 18. b. for *and* read *one*. p. 321. l. 12. t. for *consigned*, read *confined*. p. 338. last line, for *acid*, read *acid*. p. 373. l. 7. b. for *glands*, read *glans*.

LECTURE I.

INTRODUCTION.

WE may, with HIPPOCRATES, aptly compare the human, and every other animal body, to a circle; the actions or functions of it's different parts being in a state of mutual dependency upon each other, round the whole of the machine: inasmuch that at whatsoever part we begin to explain it's operations, we are obliged to assume, as known, the action of some other organ, which influences that we first treat of. Thus, if we begin with describing the circulation of the blood, as the heart is a muscle, we must suppose muscular motion understood. If muscular motion was to be first explained and accounted for, as that cannot be produced without some operation of the nerves and arterial blood, we should be under a necessity of supposing the influence of the nerves as known, and at least a part of the circulation. Again, if with BOERHAAVE we commence, by explaining the nature of the aliments before they are ingested; prosecute the successive different changes they undergo, from the mouth, to their being mixed with, and converted into blood; then describe the circulation, and so on; in the course of that method muscular motion frequently occurs, before it can be treated of in it's due order; many glands offer themselves before secretion can be explained, &c. In short, whatever method is used, the like inconvenience is unavoidable. Wherefore, that by this intricacy the begin-

LECT.ner may be as little perplexed and embarrassed as possible, we premise the following definitions, or rather short descriptions of the principal constituent and elementary parts of the body. These we have endeavoured so to frame and word, that scarce any thing shall be mentioned in the course of these lectures, whereof the learner may not, by their help, have a tolerable idea before-hand, sufficient to carry him through, until he is in the sequel more fully and more particularly informed. We shall begin with the more minute and simple, and gradually proceed to the larger and more compounded.

Fibre, in anatomy and physiology, denotes a small thread or filament, without a cavity, at least without a visible cavity; whose breadth and thickness bears a very small proportion to it's length. The least fibre of all is too minute to be perceived by our senses, however assisted. These fibres we see, are no other than bundles of many smaller ones tied together.

Membrane is a web, or rather a lamina or flough, whose thickness bears a very small proportion to it's breadth and length. Most, if not all the membranes we see in the animal body, are composed of, and resolvable into thinner ones.

Vessel, which in it's general sense signifies whatever has a cavity to contain and hold any thing, is here commonly restricted to signify the animal tubes or canals, through which fluids or juices move. The least imaginable vessel is made of the least membrane, rolled up in the form of an hollow cylinder, or part of a cone. The larger vessels, as their coats or walls must be thicker, are composed of thicker membranes, upon which smaller vessels run.

Artery is the name of that kind of vessel, which, arising originally from the heart, contains a fluid, whose motion is directed from the heart towards the extremities, and surface of the body. The larger

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larger and easily visible arteries contain red blood; LECT. I.
 are of a conical figure, slowly tapering from the heart forwards. In living animals they beat, or have what is called a pulse, answering to the motion of the heart. Their coats or walls look whitish, and are pretty thick and strong.

Veins, on the other hand, contain a fluid, whose motion is from the extremities or surface of the body towards the heart. Their coats are thinner and more transparent than those of the arteries, and therefore they appear of a bluish livid colour, the blood shining through them. In many places they have valves within them, which open towards the heart, and shut the contrary way.

Gland, denotes in general an organical texture, of a circumscribed figure, framed so as to separate from the blood a liquid different from and unlike the blood. Of these there are various kinds, some more simple, others more complex or compounded, as shall be shewn in the sequel.

A *duct*, or *excretory duct*, is a canal containing a fluid different from red blood; and is almost always the outlet of a gland or glands, or some glandular contrivance.

Nerve is the appellation of these soft white cords, which proceed either from the brain and it's appendages, within the cranium or skull, or from the spinal marrow, and are the immediate instruments of sensation; and indispensably requisite towards producing muscular motion. They are without any cavity, discernible even by the finest microscope.

voluntary

Muscle is the name of the immediate organical instrument of motion in the animal body, whether voluntary or involuntary. I have said organical, because mere elasticity is the immediate cause of some motions, as in expiration, and the restitution of the arteries. The general characteristic of muscle is, to consist of fleshy fibres, which, when acting,

LECT. contract themselves, and become shorter. This

I. contraction, according to the different circumstances of the muscle, and the parts to which it is fastened, produces different effects and different motions. If one end of a muscle is tied to a fixed part, and the other to a moveable one, when it acts, it's fibres contracting, will pull the moveable part towards that which is fixed. If both the parts, to which the extremities of a muscle is attached, be moveable, by it's action they will be both drawn towards each other. If the muscle be hollow, and contain a fluid, when it contracts, it will press upon and endeavour to expel it's contents. Such a muscle is the heart, and in some measure the stomach and urinary bladder. If the fibres of a muscle return upon themselves in the form of a ring; when they contract, they will diminish the area within that circumference. Such muscles are employed to shut cavities, and are called sphincters.

A *tendon* is a continuation of muscular fleshy fibres; it being divisible into as many fibres, or rather bundles of fibres, as the muscle itself is, to which the tendon belongs; but the tendinous fibres are more compacted and smaller, drier and harder than the fleshy fibres. They are not capable of contraction, but serve like ropes to pull when the fleshy fibres act; for the commodiousness and firmness of insertion, and for the direction of motion.

Ligaments are white, tough, flexible bodies, thicker and firmer than membranes; and not so hard or solid as cartilages (of which next) without cavity, difficultly stretched, and with little elasticity. They serve to connect parts together, and to keep the parts to which they are fixed in a proper situation, as appears remarkably in the joints or articulations. They are made up of fibrous layers or strata; the largest and strongest of which run lengthwise.

Cartilages or *gristles* are solid, smooth, white, elastic substances, between the hardness of a bone, and

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and that of a ligament, covered with a membrane LECT. I.
 called *perichondrium*, which is a-kin to the perio-
 steum of the bones. They serve to make the bones,
 whose extremities they cover, move freely in arti-
 culations. They limit the growth of bones as to
 their length, by hindering the bony fibres from
 sprouting out, and therefore when the cartilages in
 an articulation are eroded, an anchylosis or immo-
 bility of the joint is formed, by the elongation and
 coalition of the fibres of the bones that are articu-
 lated together. Sometimes they serve as ligaments
 to join bones together; and sometimes they do the
 office of bones to greater advantage than these
 would do; as the cartilages of the ribs, which, by
 their elasticity, chiefly contribute towards expira-
 tion; the cartilages that make out the brims of
 cavities, &c.

Bones are the hardest and most solid parts of the
 body, serving to support the softer and less firm
 ones in all their motions and pressures. They are
 covered with a membrane called *periosteum*, which
 is exquisitely sensible, being plentifully supplied with
 nerves and blood-vessels. The outsides of bones
 are commonly more compact than their inner parts;
 and are formed of plates, joined together by trans-
 verse fibres. Their insides are spongy and cellular,
 in which is contained marrow, within membranous
 bags, filling up the cells. This marrow, being
 more or less distributed all over the bones, and
 transfusing through their plates and fibres, makes
 them tougher and less brittle. The bones are sup-
 plied both within and without with blood-vessels
 and nerves.

These, with the different animal juices or fluids,
 are all the principal species of parts, of which the
 body is made up and consists.

But before we enter upon an account of the par-
 ticular actions or functions of the living body, it
 will be highly proper to take into consideration the

LECT. *membrana*, or, as HALLER more properly calls it,

I. the *tela cellulosa*, upon the account of it's extensive use and great importance in the animal structure. It is continued without interruption all over the body, and is insinuated into every recess. It is composed, not of fibres laid together or interwoven, nor of small tubes or vessels, though they run along it, being only adventitious, and no part of it's true structure, but of unorganised *lamellæ*, or sloughs, like fine paper. These *lamellæ* receding from one another, and partly again uniting, form cells, in such a manner as to communicate together all over from head to foot. If we conceive a honey-comb, in which every cell opens into all those that are contiguous to it, we shall form a just idea of the cellular *tela* or texture. It's cells are in some places smaller, in others larger; it is dilatable by a very small force, where it is not confined by resistance in it's neighbourhood. Where it's cells are largest, and it's texture loosest, it contains fat, as immediately under the skin, almost over all the surface of the body, between it, and the most external muscles; in the intervals or interstices between one muscle and another; in the *omentum*, *mesentery*, around the kidneys, &c. Where they are so small, as not to receive mere oil or fat, as all over the foetus, and in many places of the adult body, they contain a gelatinous fluid; or, if still smaller, a vapour of the like nature; and, if all these are wanting, they grow together.

That these cells communicate together all over the body, appears from the effects of blowing into it. Butchers, by blowing into a small wound, penetrating quite through the skin, not only raise the skin, but fill the interstices between the flesh or muscles, to make their meat look full and plump. In the living body, by a wound, air oft gets into the cellular texture, and produces what is called in surgery an *emphysema*, or a windy tumour, which

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is sometimes propagated so widely, as to cover almost the whole surface of the body; and has been found to have penetrated even into the vitreous humour of the eye. In an *anasarca*, which is that species of dropsy, in which water is contained in the cells of this web, instead of fat, or gelatinous substance, there hath been water found got into the cavernous bodies of the penis, demonstrating the extensive communication of the *tela cellulosa*. LECT. I.

This membrane, web, or texture, by laborious dissection, by blowing air into it, by injections, by maceration, hath been found to follow every visible bundle of muscular and tendinous fibres, every vessel, every nerve; every coat or membrane of the *viscera*, the brain not excepted. We shall, in the course of these lectures, find it constituting a great part of the solid substance of the most important parts, as the oesophagus, stomach, intestines, urinary bladder, &c. It even follows the periosteum of the bones, and with it penetrates into the medullary cavities. So that there is no physical point in the whole animal structure, in which there is not a portion of the *tela cellulosa*, cohering and communicating with it's main body.

It's use and importance in the animal fabric is very great. It serves as a bond of union, by tying and fastening all the parts together, yet in such a manner, as not to prevent or obstruct their necessary motions: to contain fat where fat is required; or marrow; or a thin gelly or gelatinous vapour; to render the parts smooth, moist, and flexible, and to hinder them from growing together. It yields a commodious way or road for vessels and nerves to glide along. It furnishes a considerable part of the membranes, that either line the great cavities of the body, as the pleura, and peritoneum, or immediately cover and envelop the particular viscera: of the membranes, of the muscles and tendons, veins and arteries, nerves, glands,

+ source a

LECT. and their excretory ducts; inasmuch that, faith

I. HALLER, who, of all anatomists, hath most minutely examined, and most fully and extensively considered it, *it is certain that the far greatest solid part of the body is made up of it; if it is not all entirely framed out of it originally.*

In the *tela cellulosa*, suppuration is formed; sinuses and fistula's run; incysted tumours are bred, the virulent matter in the venereal disease is propagated, and, as hath been before hinted, *emphysema* and *anasarca* are formed.

MALPIGHIVS first laid the foundation of the knowledge of the true structure of the *tela cellulosa*; anatomists before him having either no idea at all of it, or at best but uncertain, confused and inadequate notions. In his inquiries into the nature of the fat, he discovered that it was not laid together in confused heaps, but contained in distinct membranous vesicles, communicating all together; and likewise, that the vesicular texture was spread over all the body, penetrating even into the bones.

After him RHUYSCH found and demonstrated a cellular texture, where there was no fat, in many places; and therefore termed it *cellulosa*, preferably to *adiposa*. LEWENHOEK's microscopical discoveries agreed with RHUYSCH's preparations.

BOERHAAVE united all the discoveries relating to this subject, that had then been made, and digested them into a comprehensive elegant summary, in his preface to the *Leiden* edition of the *Autores varii de Morbo Gallico*.

Since that time, various anatomists have added useful observations and improvements. The accurate and learned KAW, in his *Perspiratio Hippocratica*, hath valuable things concerning it. But of all authors, the indefatigable professor HALLER, the *Gesner* of the age, hath most distinguished himself; he hath repeated the old experiments, and added

added new ones; and delivered the result of the whole compendiously, but fully in his *Primæ Lineæ Physiologiæ*. The inaugural thesis of his favourite scholar SCORINGER, *de tela cellulosa in corporis humani fabrica dignitate*, may be considered as an ample commentary on HALLER's text, as it was publicly defended, under his *Præsidium*, and highly praised and recommended by him.

LECTURE II.

Of the heart, and circulation of the blood.

WE have in our introductory lecture shewn LECT. II.
that the human, as well as every other animal living body, may be fitly compared to a circle, as all the actions or functions of it's different parts are in such a state of mutual dependence upon, and connexion with one another, that, at whatsoever part we begin to explain the animal œconomy, we are obliged to suppose or assume, as already known, something which hath not as yet been touched upon.

To prevent the beginner's being perplexed by this intricacy, we have given short and plain definitions, or rather descriptions of the different classes or species of the fundamental constituent solid parts of the body; that, where their names occur in the course of these lectures, the hearers may have some idea, not only of the meaning of the terms, but likewise of the general uses of the parts expressed by them.

We judged it also necessary to give a pretty comprehensive account of the cellular membrane or texture, which ties together all the parts, at the same time preserving their fitness for motion; and likewise contributes a large share towards their organical structure and composition.

We

LECT. We begin now to consider the machine as a-
 II. live; with it's fluids and solids moving and being
 moved; acting and being acted upon mutually
 by each other.

We shall first explain what life is, wherein it
 precisely consists.

Life consists in the action of the heart; and the
 motion of the blood influenced by that action.

Where the heart is perceived to beat, there we
 pronounce life to be, though no other function be
 exercised. And where we are certain that the heart
 is entirely at rest, we cannot with reason affirm that
 there is life.

The action then of the heart propelling the blood
 is corporeal life; and where there is only this action,
 and no other, there is the smallest degree of life.

But this smallest degree of life would quickly be
 at an end, if there was no other function added to
 it. The manifest function most immediately con-
 nected with it, and most necessary towards it's sup-
 port and continuance, is respiration or breathing.
 Hence living and breathing are joined together in
 stile to fill up the idea, and express durable life. If
 respiration is stopped any how in a born animal,
 that is furnished with lungs, life is quickly de-
 stroyed.

But farther, as the heart is a muscular organ,
 which by it's contraction propels the blood; and
 as some influence or other of nerves is indispen-
 sably requisite to exercise muscular motion, as was
 observed in the definitions; and as the nerves of
 the heart are propagated from the brain (by which
 I mean in general all that pulpy substance within
 the cranium, whether brain strictly so called, cere-
 bellum or medullary substance) I say, as the heart
 is supplied with nerves from the brain, some action
 or influence of the brain and nerves, whatever that
 be, is necessary to maintain the action of the heart.

CIRCULATION OF THE BLOOD.

11

So that, to put all together, the action of the heart propelling the blood; respiration or breathing; and the influence of the brain and nerves, that causes and keeps up the action of the heart, must concur to constitute life of any considerable duration; such as we are now considering.

Here let us observe by the by, that in the living animal body, there is a real perpetual motion; the heart, the organs of respiration, and the brain, act upon one another in a circle with an undiminished force, while the structure of the machine, and the condition of it's fluids, remain unimpaired. But mathematicians demonstrate that such a perpetual motion is impossible to be exercised in mere matter. It follows therefore, that the sentient moving principle is immaterial. But to return to our subject,

As therefore life, properly and precisely speaking, consists in the action of the heart, and the motion of the blood thereby influenced, we shall first consider and explain these, then pass in order to the other functions that are most closely connected with them.

Before we consider the action or functions of the heart, we shall lay before you a general view of it's situation, it's connexion with the neighbouring parts, and it's fabrick or structure, as far as is necessary to comprehend the account we are to give of it's action. In this course of lectures I promise to give little or no more of the anatomical part than this amounts to, as I shew not the parts themselves, without doing which minute descriptions are difficultly comprehended, and therefore the connexion between the function and the structure may very oft be lost.

The heart is situated in the left part of the thorax or chest. It is nearly of the shape of half a cone, that is the segment of a cone cut through it's axis from it's apex to it's base, with a blunt apex or point. It therefore hath one side pretty plain or flat, and the other round or convex. It lies transversely, and somewhat

LECT. somewhat obliquely, in such a manner that it's flat side rests upon the diaphragm, with it's largest end or basis towards the right, and it's apex or point towards the left side; the apex being somewhat lower than the basis.

The heart is covered all over with a very strong and tough membranous bag called *pericardium*. This bag is firmly fastened to the great vessels that enter into, or issue from the heart; and to the diaphragm. But it is loose from the body and apex of the heart; and as it is larger than the heart contained in it, it allows it room and liberty to be contracted and dilated freely, and without confinement.

The use of the *pericardium* is first, to add to the firmness of the support of the heart, it being, as I have said, not only fastened to the great vessels, but likewise to the diaphragm; but chiefly to confine within it a watry warm vapour, to preserve the surface of the heart moist and smooth, and pliable to it's incessantly reiterated strong contractions and dilatations: and therefore all animals, that have two ventricles to their hearts, are furnished with a *pericardium*.

The heart itself may be fitly divided into it's body, and two appendixes called auricles. It's body comprehends two large cavities called ventricles. Both the auricles and ventricles are commonly distinguished by the names of right and left; though considering the true position of the heart, they might be more properly termed superior and inferior. But we shall retain the usual names.

The right ventricle is the wider and shorter of the two; the left the narrower and longer, reaching farther towards the apex of the heart than the other. The left is likewise much stronger, and it's walls thicker. There is a very thick impervious septum or partition betwixt them, hindring all communication

II.

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10-10-10

X
1
Tendron

Left tricle, without communicating with the auricle of
II. that side.

The two or more large trunks of the veins, belonging to, and returning from the lungs, in like manner form a *sinus*, opening into the left auricle.

The right ventricle sends out of it's upper and wider part a large arterial trunk, called the pulmonary artery; which is distributed through the substance of the lungs, dividing into smaller and smaller vessels, and branches as it proceeds.

The left ventricle sends out likewise, from it's upper and wider part, another large arterial trunk, called the *aorta*, or *arteria magna*, which by it's ramifications is distributed all over the body.

We have then two auricles and two ventricles; the auricles opening into their respective contiguous ventricles; the auricles receive each a large venous pouch or *sinus*; and the ventricles send out each a large arterial trunk. Let us now begin to consider the action of the heart; and rudely sketch out the course of the blood from and back again to the heart; commonly, and not improperly, called it's circulation; which shall be more accurately and minutely described afterwards.

But first let us remind you of what was said in the definitions concerning a muscle; to wit, that it's essential characteristic is to consist of fleshy fibres; which, when acting, contract themselves: that therefore, if the muscle be in the form of an hollow vessel, and contains a liquid, it will by it's action endeavour to expel that liquid. This, I say, we must remind you of, and assume as known, until we come to treat professedly of muscular motion.

The blood returning through the lesser veins, from the different parts of the body, is at last gathered into the two large venous trunks already mentioned; to wit, the *cava ascendens* and *descendens*, which meet at the right auricle. This conflux or
sinus

sinus opens principally into the right auricle; but likewise partly directly into the ventricle. The auricle and sinus, when filled to a due degree, being irritated by the blood filling and distending it, contracts by it's muscular power, and propels it's contents into the right ventricle, with which it hath a patent communication.

This right ventricle, when sufficiently filled, partly by the blood which filled the auricle, and partly from that which comes into it directly from the sinus, without touching at the auricle at all, (for as the ventricle is greatly more capacious than the auricle, all the blood the latter could throw into it could not sufficiently distend it, and furnish such a quantity, as it throws out at every contraction): I say the right ventricle, when sufficiently filled and distended, likewise being irritated, exerts it's muscular power, and by it's contraction forces the blood it contained into the pulmonary artery, that rises out of it; and so through the lungs; from which it returns by the pulmonary veins into the left auricle, from thence it is propelled into the left ventricle, which sends it into the aorta, and through it's small branches distributes it over all the body. From the smallest branches of the aorta it is taken up by the smallest veins, which are only the minute arteries continued, and turned back towards the heart; and by them it is again returned to the venous sinus and right auricle; and this circulation is incessantly reiterated.

To represent it still more compendiously, the blood from the conflux of the *cava ascendens* and *descendens* flows into the right auricle, and from thence into the right ventricle. From the right ventricle it is sent into the lungs through the pulmonary artery, and by the pulmonary vein returned to the left auricle, from that into the left ventricle; out of which it is propelled through the
aorta,

LECT. *Aorta*, and by it's minute ramifications distributed
 II. all over the body, then being taken up by the beginnings of the veins, is again brought to the right *sinus* and auricle: and this rout is renewed and continued without cease.

This is a rude sketch of the course of the circulating vital fluid, of which we have as yet only drawn the outlines, that the beginner might not be embarrassed by attending to too many things at once. We shall as we proceed finish higher, and add more truth to the piece.

And first let us observe, that the muscular contractions of the auricles are not performed in the same successive order of time we were obliged to mention them in for method's sake; but the two auricles contract at once, and during their action, the ventricles are passive, suffering themselves to be dilated and filled.

And vice versa the two ventricles, when completely filled, contract at one and the same time, and while they are contracting, the auricles are filling. In this manner are the auricles and ventricles alternately filled and evacuated, as appears not only from the nature of the thing, but from the opening of live animals, and not in the manner proposed by an excellent anatomist; whose account of the motions of the heart, different from what I have given, and what is universally received, hath met with a general disapprobation both at home and abroad.

Now that these alternate contractions and dilations, these fillings and emptyings might be performed completely and truly, with an uniform and regular constancy, nature (by which I all along understand the supreme author of nature) hath placed wonderful contrivances where they are required; which we shall now briefly explain.

When the right auricle and *sinus* is contracting, the current of the blood flowing towards the auricle, together

together with the weight of that portion of it, which L e t.
 returns from the head and upper parts by the *vena* II.
cava descendens, determines the blood contained in
 the right sinus and auricle, upon their action into
 the contiguous ventricle.

Now from the mouth of the ventricle there
 arises all around a membranous broad ring, which
 is undivided at it's origin, but, when extended into
 the cavity of the ventricle, parts into three unequal
 portions or scollops, the extremities of which being
 strengthened by tendinous fibres, are fixed partly to
 the walls of the ventricle, and partly to the fleshy
 columnlae within it, (of which more by and by)
 but in the intermediate spaces, betwixt their origin
 from the mouth of the ventricle to their fixt points
 within it, are free and loose. These three unequal
 portions of this membrane being somewhat trian-
 gular, are called *valvulae tricuspides*.

While the blood, by the contraction of the *sinus*
 and auricle, is propelling into the ventricle, this
 membrane and it's scollops give way to the current,
 being pressed to the sides of the ventricle; and par-
 ticularly the largest portion is made to cover the
 passage into the pulmonary artery, that no blood
 may get into it by the feeble effort of the auricle,
 but wait for the due *impetus* from the ventricle.

When the ventricle being sufficiently filled and
 irritated contracts, it's cavity being every way dimi-
 nished, (and when the contraction is completed, the
 cavity is quite annihilated, the ventricle being per-
 fectly emptied) I say, when the ventricle contracts,
 the blood seeking an outlet every way, and getting
 between the walls of the ventricles and the loose
 parts of the membrane or valves, drives them in-
 wards towards the axis of the ventricle, and to-
 wards the auricle and sinus, so as to hinder the re-
 turn of the blood by the way it came. They are
 stayed by their insertions into the walls and *colum-
 nula* of the ventricle; and hindred from being
 driven

LECT. driven too far back and strained. At the same

II. time the orifice of the pulmonary artery, that before was covered by the largest of the valvular portions, is now left open; and it being the only outlet the blood can find, it's course is all determined that way, and it rushes into the pulmonary artery with the full force of the contraction of the ventricle.

There is another contrivance much of the same kind to hinder the return of the blood into the left auricle and *sinus*, when the left ventricle is contracting; with this difference, that instead of three in the right, there are in the left only two membranous productions or valves, and these, from some similitude to a mitre, are called *valvulae mitrales*.

There are besides, at the mouth of the pulmonary artery, and at the mouth of the aorta, in each of these places, a set of valves, three in each set, called from their figure *sigmoideae* or *semilunares*. These, when the blood is expelled out of the ventricles by their contraction, give way, and are pressed flat against the walls of the arteries. But when the ventricles are emptied, and the arteries begin their contraction, the blood seeking an exit every way, gets between the loose margin of the valves, and the walls of the arteries, and so forces all three back at once. And they are of such a figure, that when pressed fully back, they are united nearly into the figure of a circle (like the head of a drum.) But as, without some special provision, there would be something of a vacancy in the middle of this circle, of a triangular figure, nature hath placed in the middle of the margin of each valve, a round fleshy substance, or *papilla*, all which three, when pressed together, fill up so much space, and strengthen the middle weak spot, making the valves play firm and true.

All

All these different sets of valves; to wit, the *tri-* L E C T.
cuspides at the entry of the right ventricle; the *mi-* II.
trales at the entry of the left; and the two *semilu-*

nares at the mouths of the great arteries, that issue from the ventricles, may be compared in some measure to locks made on navigable canals; which, when a boat or bark hath got so far, by being shut after water is let in, prevent the boat from being driven back, and secure the progress already made.

These valves are more conspicuous and robust in the left side of the heart, than in the right, as the left ventricle is vastly thicker and better stored with muscular fibres; and therefore, contracting with greater force, requires a firmer structure of valves to stand the stress they are put to.

But over and above all this, there are within each ventricle, and in an inferior degree within each auricle, fleshy muscular productions or columns, which we had occasion to mention before, some running one way, and others another, firmly attached at both ends to the sides or walls of the ventricles. The uses of these are manifold.

1st, They hinder the heart's being strained beyond measure during it's diastole or dilatation.

2dly, They assist in the systole or contraction of the heart, by contributing their share of muscular contraction, as they consist of fibres of the same nature and properties with these of the walls of the ventricles.

3dly, They conqassate and help to keep fluid the blood which is so often repeatedly dashed against them.

4thly, Some of them support some part of the *valvula tricuspides* and *mitrales*, and direct and determine their playing.

And lastly, by filling up room, they render the complete evacuation of the ventricles practicable; which could not be brought about otherwise; as an

LECT. hollow muscle, if it were quite smooth and even,
 II. in the inside, could not by contraction altogether
 annihilate it's own cavity.

So many various and important ends hath nature gained at once by this plain and simple mechanism!

The heart, besides the great vessels that either open into it, or issue from it, hath proper vessels of it's own, called coronary, pervading it's substance, and supplying it with vital fluids; both arteries and veins. The arteries, almost always two in number, arise from the great trunk of the *aorta*, a little beyond the semilunar valves, and furnish the heart with innumerable branches. RHUYSEN hath given an excellent figure of their origin and distribution.

The evanescent branches of these arteries terminate in beginning veins, as in other parts of the body; and the trunks of these veins empty their blood some of them into the right *sinus* and auricle, others into the right ventricle; and some, but fewer, into the left *sinus* and auricle, and left ventricle.

By this means the heart is supplied with the vital stream expeditiously to influence it's restless and rapid functions.

The celebrated BOERHAAVE, from the consideration of the coronary arteries taking their rise beyond the valves of the *aorta*, and their returning to the heart by a retrograde angle, maintained that they are filled by the reflux or regurgitation of the blood caused by the systole of the *aorta*; and therefore that their pulse or diastole is opposite in time to that of the *aorta* and it's other branches, and synchronous to that of the heart.

HALLER maintains the contrary; but, with submission to so great a man, I think he never had less reason to differ from his master than upon this occasion. For, besides that upon the account of the retrograde angle, it is natural to think that very little

little blood can be propelled into the origin of the coronary vessels till after all the other branches are served, I think if we consider, that when the *aorta* and it's branches are in their diastole, the heart is then in it's systole, and therefore not in a condition to allow the small branches distributed through it's substance to be dilated and filled, we must incline to believe BOERHAAVE to have been in the right.

LECT.
II.

When the arteries restore themselves, the angle which the coronary trunks make with the *aorta*, will favour the admission of blood into them, and the ventricles of the heart, being then dilating by the blood poured into them from the auricles, the blood transmitted through the coronary arteries, must, one would imagine, be more easily propelled into the capillary terminations of these arteries, than when the ventricles are in their systole, as they are dilated with a much less force than they are contracted with: they are dilated only by the force of the sinus and auricle, but they are constricted by their own muscular force, which, as the quantity of muscular fibres in them is vastly greater than in the sinus and auricle, must be very much superior.

HALLER supports his doctrine by an experiment. Having opened the thorax of a live animal, upon cutting one of the coronary arterial trunks, he finds that the blood springs out of it to a greater height or distance, when the heart is in it's systole than when in it's diastole; and thence concludes, that the blood is propelled through the coronary arteries then; which is, when the *aorta* is in it's diastole. But it seems to be doubtful whether the consequence follows. Though, when the coronary artery is cut asunder, the blood contained in it may be squirted out of it with a greater force during the systole of the heart than in it's diastole, yet if that trunk remained entire, it's branches might be compressed by the force of the systole, so as to hinder it's ready

LECT. progress through them, and oblige it to wait for
 II. the diastole to have a freer course.

So much for this controversy; but, whether the one or the other opinion is right, no very important consequence seems to be implied. At least practice is not in the least affected. Might it not be compromised, and a medium struck, by admitting that blood gets into the coronary arteries, both by the systole of the ventricle, and the systole of the arteries, the latter completing what the former had begun? By this means the circulation through the substance of the heart is rendered more expeditious, and better secured than elsewhere, which it's incessantly rapid functions seem to require.

We have before mentioned to you that the contraction and dilatation of the auricles and ventricles is alternate. Quæritur, why are these motions alternate? What are the physical causes of this alternation?

This question hath extremely puzzled anatomists and physiologists these thirty years past or more; and several hypotheses have been broached and elaborately dressed out to solve it. But, as it often is the case in physical researches, what appeared so extremely abstruse, and almost beyond human comprehension, may be accounted for in the most simple manner. HALLER, as far as I know, was the first who hit off the true solution, or at least the first who completed it. Dr. WHYTT after him hath clearly and fully explained it in his ingenious and instructive book on the vital motions, &c. of animals.

The principle upon which the solution proceeds is, that a muscle in the live animal body, when irritated, contracts, and thereby endeavours to rid itself of the irritating cause, which when it hath effected, it returns again to it's inactive state, in which it remains till, a fresh effectually stimulating cause is furnished. The irritating causes, that being

ing applied to a live muscle, stimulate it into contraction, are such as have a natural tendency to violate or destroy the organical texture of it's fibres, as hard bodies that may hurt by pricking, cutting, or tearing; distention by any fluid, if the muscle is hollow; heat; and some degree of sharpness or acrimony in fluids touching the fibres. These causes are found by experiments to stimulate a live muscle into contraction; which contraction so excited is an involuntary motion to shake off the offending cause. But of this we shall have occasion to discourse more ~~fully~~ afterwards, when we treat ~~professedly~~ of irritability.

II.

and even an
unusual
degree of
force.

To apply this doctrine to the heart, when by the current of the venous blood, urged on by the systole of the arteries, a sufficient quantity of it is impelled into the right auricle and *sinus*, so as to irritate them enough, they by their muscular energy contract; and throw their contents into the corresponding ventricle; and so rid themselves of the stimulus *pro hac vice*, remaining in a condition to be irritated anew, when a like cause is applied.

The corresponding ventricle, by the blood's being thrown into it, is irritated in like manner as the auricle was the moment before, and therefore likewise contracts; and frees itself from the irritating cause, by throwing out it's blood the way it will go.

Now as that identical quantity of blood that caused the contraction of the auricle this moment is to be the cause of the contraction of the ventricle the next, it is evident that the contraction of the auricle and contiguous ventricle must be alternate; it being impossible they should be irritated both at one and the same point of time, because the stimulus is not applied to both at once, but to the one after the other.

But by all means carefully read Dr. WHYTT'S two sections on the heart; where he not only clearly

and at large explains and proves this account of the alternate systole and diastole of that organ, the chief source of life; but likewise confutes all other solutions that have been offered, and are worthy of consideration.

LECTURE III.

Some diseases of the heart. Circulation through the arteries and veins. Of aneurism; and varix.

LECT.
III.

WE have in our last lecture, after explaining the structure of the heart, exhibited a general sketch of the circulation of the blood; and discoursed particularly and minutely on these circumstances of it, which immediately concern the heart itself; and in so doing have given an account of the action and uses of the different parts of the heart.

We have seen the rout of the blood to be from the meeting of the two trunks of the ascending and descending venæ cavæ into the right sinus and auricle of the heart; from thence into the right ventricle; from thence through the arteria pulmonalis into the lungs; from which it returns by the pulmonary veins to the left sinus and auricle; from thence it is sent into the left ventricle; out of which it is expelled through the aorta, and by it's infinitely numerous ramifications distributed all over the body; and at length is taken up by the beginnings of the veins, which are a continuation of the most minute evanescent arteries; and by them returned to the right auricle and sinus, from which we considered it first starting. And thus it repeats it's incessant round.

We have seen that the auricles and ventricles of the heart act by their muscular force, and that this force is excited by the irritation of the blood thrown into them successively, and distending their cavities; and therefore the contraction and dilatation;

of systole and diastole of the auricles and ventricles must be alternate. LECT. III.

We have likewise considered the wonderful contrivances of nature to make all these motions true and complete; to wit, valves which hinder the blood from being beaten back towards the places from whence it came; and the fleshy inequalities or columnæ in the insides of both auricles and ventricles, especially the latter, by the assistance of which, besides other important ends, the complete evacuation of these cavities is effected.

We should now proceed to deliver what remains next to be particularly explained of the circulation; to wit, that part of it which immediately relates to the arteries and veins.

But while the structure of the heart is fresh in your memories, we shall, agreeably to the plan of these lectures, consider some of the most remarkable diseases of that part.

But here let me acquaint you that you are not to expect any very particular detail of these distempers. All that can be done in this compendious course being only to give a general idea of their nature, and the general curative indications, where they are curable; that thus the usefulness of such a course, and it's connexion with regular and rational practice may clearly appear.

The first distemper we shall take notice of is the Dropfy of the *pericardium*. Dropfy of the pericardium.

We observed that the principal use of the *pericardium* is by it's close impervious structure to confine within it's cavity a warm aqueous animal vapour, to moisten and lubricate the surface of the heart; and thereby to preserve it in a fit trim to continue it's incessant rapid actions; and therefore that every animal, whose heart hath two ventricles, is furnished with a *pericardium*.

This vapour must be supplied by extremely small vessels opening into it's cavity, either from the convex

LECT. Vex surface of the heart, or the concave surface of
 III. the *pericardium*, or both. It cannot come from
 without the *pericardium*, for the same impervious
 structure, that confines it when collected, must ex-
 clude it's admission *ab extra*.

It must likewise be constantly renewed; that is, some of the old must constantly be reabsorbed, while the new is gathering. If it were always accumulating without any part being carried off, the heart would soon be drowned in water. If there was no fresh vapour ever admitted, what is already within the *pericardium* would in process of time become rancid and acrid; and therefore unfit for it's purpose, from the nature of animal juices, which tend to alkaline acrimony, especially when pent up in so warm a place.

Therefore there must be a constant renewal of this vapour, and that the same, or nearly the same quantity of vapour may be kept up, there must be the same, or nearly the same quantity furnished anew, as there is absorbed.

But if the quantity reabsorbed is remarkably less than that furnished anew, the quantity of vapour must gradually increase. And as the vapour is only water or lymph, impregnated with animal principles, and rarefied; as it's quantity increases, since it cannot make it's escape through the *pericardium*, it will become denser and denser, and at length become downright palpable water.

This is the origin of water or dropsy in the *pericardium*; and not only of this one sort of dropsy, but of every kind that is formed within any remarkable pre-existent cavity whatever. Such is the importance of the knowledge of the animal oeconomy in the practice of physic.

Ascites.

Thus an *ascites* is only the same thing happening within the *peritoneum*, which we have been now explaining, concerning the *pericardium*. In the cavity of the *abdomen* there is a vapour, which hinders

hinders the parts from growing together, and to L E C T. III.
the *peritonæum*. This vapour is remarkably observable in opening a new killed animal, while it is warm.

If this vapour is not absorbed as fast as it is new furnished, an *ascites* ensues, and not, as hath been imagined by anatomists in the last century, from the rupture of lymphatic vessels.

The general causes of dropsies are a poorness of blood, whereby it's watry parts abound too much, and are too easily separable from it's other principles; together with a weakness or laxity of the solids.

The indications of cure are, besides letting out the burthen some water by chirurgical operation, where it is practicable, discharging it by hydragogue purges, and diuretics, thereby promoting it's reabsorption by emptying the vessels; and restoring the tone of the solids by proper strengtheners, friction, and exercise. A drying diet is here indispensibly requisite.

Water is collected in the same manner in the *thorax*, between the folds of the mediastinum; and that is called *hydrops pectoris*; in the ventricles of the brain, and there it creates lethargy or apoplexy: within the *scrotum*; and in other places.

Anasarca is an effusion of water in the *tela cellu- Anasarca. losa*, instead of fat, or a gelatinous fluid, as hath been hinted in the introductory lecture; and differs from *ascites*, and other local dropsies, by having no circumscribed seat.

The next disease we shall touch upon is *polypus* of the heart.

This is a flesh-like concretion found in the ven- Polypus of tricles of the heart, or the beginning of the trunk the heart. of the aorta. I speak not of these slight coagulations, which are found within the heart in most subjects, and which are formed there in the agonies of death, when the heart contracts so weakly, as not

LECT.

III.

not to expel all it's contents, and so gives the blood time to form into clots by stagnation in it's cavity. But I mean these more solid concretions, which are rooted amidst the fleshy productions or columns of the ventricles; and which by their firmness evidently appear to have been of some considerable standing.

But the causes of both are the same: part of the blood thrown into the ventricle remains there amidst the interstices of the fleshy productions; and not being afterwards expelled, becomes the *nucleus* or bottom, to which every succeeding impletion of the ventricle makes a new addition of substance, by the adhesion of some part of it, especially it's serum to the *nucleus*. The strong action of the heart compacts all into a firm substance, and makes it fast to the walls of the ventricles, amidst the interstices of the fleshy productions, by the attraction of cohesion. In the mean time it's bulk increasing, it extends itself which way it best can, and multiplies it's roots or feet; whence it hath it's name, *polypus*, that is *multipes*, many-footed; and creates uneasy symptoms, the principal and most distinguishing of which is a grievous palpitation of the heart upon slight motions of the body; and at length death is caused by it's motion being totally stopped.

Those persons are most liable to *polypus* of the heart whose blood is very thick, and who are of an atrabilarious temperament; especially if they at the same time are liable to fainting fits; which give the blood opportunity and time to coagulate within the heart.

There is no cure that I know of mentioned by authors for this dreadful disease. What seems to me to bid fairest for one is the constant use of soap, or a proper *lixivium*, washed down with great quantities of a decoction of grass roots, or of grass itself in the summer time, continued for a long time together.

together. Grass and it's roots we know to be the most dissolvent of all vegetables, and perfectly safe. LECT. III.

And from the way of administering Mrs. STEPHENS'S medicine we learn that soap and lixivium may be persisted in, without remarkable detriment to the general health, for a much longer time together, than otherwise we durst venture to advise it. Fresh made cow's, sheep's, or goat's whey may be a proper succedaneum to the decoction of the grass roots, or grass.

But it is time we should now return to the animal œconomy.

We have already considered the motion of the blood through the heart, in all it's parts; we shall next trace it's course through the arteries and veins, and explain the different offices of the arteries and veins.

We shall begin by laying before you their structure, and their manner of being branched out and distributed.

As we have said before in the definitions, arteries are canals or vessels, which convey the blood directly from the heart to the other parts of the body. They are in colour whitish, and more so in dead subjects than in living bodies, as the small vessels, that run along their membranes, are then empty and collapsed. They are conical, tapering gently from the heart forwards, which appears most evidently in the larger arteries, where they run a remarkable way without sending off branches. But, as the number of branches increases by division and subdivision, they gradually come nearer to a cylindrical figure; till at length in the smallest branches of all, which are termed capillaries, that is as small as hairs, though in reality they are much smaller; their figure is altogether cylindrical. These capillaries are continued to the origins of the veins, the latter being no other than the former turned back towards the heart.

At

LECT.

III.

Atevery division of an arterial trunk into branches, the sum total of all the cavities of the branches is always greater than the cavity of the trunk, from which they immediately proceed.

So that the cavities of all the capillaries taken together must be immensely greater than the cavity of the aorta, where it issues from the heart.

Such arteries, as are large enough to be examined by anatomical methods of enquiry, have been found to consist of the following different coats or membranes.

The outermost of all is an adventitious thin membrane, continued from the general membrane of the neighbourhood where the artery runs; as in the *thorax* from the *pleura*, or from the *pericardium*; in the *abdomen* from the *peritonæum*; in passing through the *cranium* from the membranes of the brain, &c. This coat is, as I have said, adventitious, and only follows the artery for a space, and then abandons it; and therefore is properly speaking no part of the artery.

The next coat to that is found to be cellular, of the texture we have described in the introductory lecture. And in this coat the texture becomes closer and more compacted, as it approaches nearer to the cavity of the artery.

The coat immediately under that is muscular, or at least fibrous, and muscular like. It's fibres are circular; not indeed continued quite round; but disposed in a better manner for cohesion and strength; to wit, each of them describes the far greatest part of a circle; then as it were sinking down, is fastened to the rest of the same kind. This happening to different fibres in different parts of the cylindrical wall of the artery; and there being several *strata* or layers of such fibres makes a firm coat, and constitutes the chief strength of the artery, either to resist dilatation and rupture, or to restore itself when distended to it's former narrowness.

This series of circular fibres appears in some places of the aorta to be fleshy and truly muscular.

LECT.
III.

Immediately under this coat, betwixt it and the innermost of all, there is some cellular substance, which being very short and minute is difficult to be demonstrated; but after long maceration in water is to be shewn.

The innermost coat, that which the blood rubs against in gliding along, is a fine thin membrane, smooth in the inside, being polished by the fluid current. By due maceration it may be separated from the cellular texture, that lies between it and the muscular coat.

It serves as a lining to the other coats; and to hinder the globules of blood from separating and tearing asunder the muscular fibres; and therefore contributes not a little to the strength and durability of the arterial frame.

Besides these coats and membranes, there are blood-vessels, both arteries and veins, that run upon the coats of the larger arteries; and nerves likewise. These run in the outermost cellular substance under the first and adventitious coat. The arteries by successful injections appear very numerous, as may be seen in Rhuyssen's figures.

This account of the coats of arteries is agreeable to the latest discoveries of anatomists, and very different from older descriptions. The reason of the difference seems to be, that till very lately anatomists had no distinct knowledge of the tela cellulosa; at least did not know that it insinuated itself so universally into the structure and composition of almost every part. And thence it is that arbitrary and improper names are by older anatomists given of the different membranes that compose the vessels and viscera, according to the fancy of the anatomist; as vascular, glandular, nervous, &c. coats.

We

LECT. We now pass to the veins. The veins arise, as
 III. we have before observed, from the small evanescent
 arteries becoming cylindrical, and turned towards
 the heart. From numbers of small twigs uniting
 larger and larger trunks are gradually formed, till
 at length they are gathered and united into the great
 venous trunks that open into the heart.

They are, like the arteries, branched out in such
 a manner, that the sum total of the diameters of the
 branches is always greater than that of the trunk
 they compose.

Their coats are thinner than those of the arteries,
 (which thinness renders them in some measure trans-
 parent) but their texture is closer; and, according
 to Dr. WINTRINGHAM'S experiments, tougher and
 stronger, in proportion to their thickness, than that
 of arteries.

They are very difficultly separable into distinct
 series of membranes; and it is but in a few places
 where any thing like muscular fibres can be found
 in them.

When they are emptied and cut through, they
 do not maintain their circular sections as the arteries
 do, but fall flat, and so discover less elasticity.

They are both larger and more numerous than
 the arteries, as may appear from the many large
 cutaneous veins, that have no such arteries corre-
 sponding to them. Insomuch that the sum total of
 their cavities may be fairly reckoned four or five
 times larger than that of the arteries.

Within their cavities in many places there are
 valves, that is, pretty strong membranous substances
 like trap-doors, the one end of which is fixed to the
 inside of the walls of the veins, and the other pro-
 jects loose into it's cavity towards the heart. They
 are most commonly placed together in pairs, some-
 times single, and sometimes triple. Their use is to
 prevent the blood's being beaten back through the
 veins by any force or pressure, whereby the uniform
 reflux

reflux of the blood to the heart might be disturbed. LECT. III.
 And so truly are they adapted to that purpose, that if you try to inject any fluid into a venous trunk furnished with valves, from the heart towards the extremities, it will burst before the valves give way: and hence the venous system cannot be injected and demonstrated like the arterial.

For the different places of the body, in which veins are furnished with valves, I must refer you to anatomists; and particularly to FABRICIUS AB AQUAPENDENTE, who hath wrote a treatise *De Venarum Ostioliis*, and illustrated it with large figures.

Having delivered the structure and principal properties of the arteries and veins, we come now to explain minutely, the way and manner in which the circulation of the blood is carried on from the left ventricle of the heart and the beginning of the aorta, back to the right auricle; that is, the motion of the blood through the arteries and veins.

Let us suppose the left ventricle already fully distended with blood just beginning it's systole or contraction. At this precise point of time the arteries are the emptiest, having immediately before restored themselves by their contractility to their greatest narrowness. The ventricle by it's muscular force, which is very great, throws it's contents into the aorta. The blood, *a tergo*, pushes on that before; that before creates a resistance to that coming behind, through the whole arterial system. As the arteries by being divided and subdivided become gradually smaller and smaller, the resistance is gradually increased by the increase of the surface, and the friction which is proportionable to the surface; and therefore at the capillaries is greatest of all; in which microscopes have sometimes shewn a single red globule of blood filling the whole cavity of the vessel. This resistance is somewhat inanced by the tapering figure of the arteries.

+ Tho!
 believe very
 So little,

L. E. C. T. So that when all the blood is thrown out of the
 III. ventricle, the arteries, by the quantity and *impetus*
 of the blood thrown into them, and by the resistance it meets with in it's progress, especially in the capillaries, must be distended, as they are yielding and dilatable; and this state of distention, which is called their diastole, must keep time with the contraction or systole of the heart.

But when the arteries are fully distended, as the *impetus* ceases, the distending fluid being no more supplied, they will be left at liberty to contract themselves, which they do either by the muscular action of their circular fibres, or by their natural elasticity, or both, (but I believe much more by the latter than the former) and so endeavour to expel the blood out of their cavities, which, agreeably to the nature of a fluid, will endeavour to recede from the pressure, wherever there is a way.

But there can be no other way for the blood to make it's escape, but either back towards the heart; or forwards into the veins: (unless the arteries should burst, which is out of the question.)

Now in the effort the blood makes to return back to the ventricle, it forces back the three semilunar valves at the mouth of the *aorta*, which, when fully acted upon, are united together into one complete circular surface, as we have already explained, and so prevent all regurgitation that way, except perhaps into the orifices of the coronary arteries.

And as the veins are in their beginnings extremely small, being only the arterial capillaries continued and turned towards the heart; and by uniting, form gradually larger and larger trunks, the blood will be urged through them with a pretty constant and uniform current: for both the diastole and systole of the arteries will keep urging it on. This current, the larger the veins are, and the nearer to the heart, will be the more rapid; because the diameter of the cavity of every trunk of a vein is less than

than the sum total of the diameters of all the branches that compose it, though it is always larger than any one of them singly. So that the velocity of the motion of the blood, in the two great trunks of the cava ascendens and descendens, will be the greatest of all, where they open into the right auricle and sinus; and therefore be sufficient to supply blood quickly enough to be propelled and pass through the heart.

The dilatation or diastole of the arteries is called the pulse; which is so much attended to in the practice of physick. The veins have naturally no pulse, because in them the blood flows from smaller canals into wider; its current into their beginnings is more equal and uniform; and the stop, or remora at the right sinus and auricle is next to nothing; for while they are filling, the venous blood is proceeding on, and while they are contracting, there is room making for it to be accumulated; so that in a natural state there is no cause worth considering to drive it back into the venous system; and therefore the venous system can naturally have no pulse, at least none that can be distinguished in any vein so remote from the heart, that we can examine it in. Besides, their structure is not so susceptible of pulse as that of the arteries, even though the same causes should be supposed to act upon them; as they are not easily dilatable beyond their common tone, nor have they that contractile power to restore themselves when dilated, that the arteries have.

On the other hand the arteries are easily dilatable, and capable of again restoring themselves; they are filled with great force and rapidity, by the sudden squirt of the left ventricle, and the resistance at their capillary terminations is very great.

I said the veins have no pulse naturally; but in dying persons, or in a state analogous to that of

LECT. dying persons, there has been sometimes perceived a
 III. fluttering in the veins, somewhat like a pulse, occasioned by an extraordinary stop at the heart, which causes a repulsion of the blood from the right auricle into the trunks of the veins at the heart.

Thus we have hitherto gone through the action of the heart and the motion of the blood through it; and it's course through the arteries and veins back to the heart.

There remains now, to complete our account of the circulation, to describe it's passage through the lungs; but as respiration is necessary to expedite that passage; and as that function demands a particular lecture by itself, we shall here only briefly acquaint you beforehand, that the modus of the circulation of the blood through the lungs is in general the very same with that in the rest of the body; to wit, the blood is thrown out of the right ventricle of the heart into the pulmonary artery and all it's ramifications. The pulmonary artery hath semilunar valves near it's origin like these of the aorta, which hinder the regrefs of blood towards the heart. These arterial branches no doubt have some kind of pulse like the branches of the aorta; and propel in the same manner their blood into the beginnings of the pulmonary veins; and at length to the left auricle. So far they agree with the vessels of the rest of the body. The material difference is, that respiration is necessary to co-operate with the action of the ventricle, in order to propel the blood through the lungs.

Now if we assume this as explained, we have had the whole of the circulation before us; and should next go on to give an account of it's discovery, the proofs of it's reality, and shew it's infinite advantage to rational medicine; but we choose rather to begin a new lecture with these important matters; and shall fill up the remainder of this with some practical remarks, agreeable to our plan, to shew the

DISEASES OF THE HEART, &c.

37

the connexion of the knowledge of the animal œconomy with that of diseases and their cure. L E C T. III.

We shall then take into consideration the nature of aneurism; and that what I am going to deliver concerning it may be the more clearly understood, it will be necessary to call to remembrance what hath already been said of the structure of arteries.

Aneurism is of two kinds, the true and the spurious. A spurious aneurism is caused when by a wound, as by the prick of a lancet in blood letting, the wounding instrument hath penetrated into the cavity of the artery; by which means it happens, that in every pulsation some blood is thrown out into the neighbouring cellular substance, and interstices of the parts; which being accumulated, and hardening, ~~its more liquid parts being dissipated, and the remainder coagulated,~~ forms a tumor above the wounded place of the artery, without pulsation, or at most with a very obscure one.

From the structure of arteries I think it is plain, that only the spurious kind can be occasioned by a wound or the prick of a lancet. For if the wounding instrument only cuts through the cellular coat without penetrating into the fibrous or muscular one, the wound would beyond all doubt be healed before the muscular coat could be gradually distended to such a degree as to constitute a true aneurism. Besides, the cellular coat does not contribute so much to the strength of the artery, as that it should be distended into a sack when that is cut through.

If the fibrous or muscular coat is partly cut through, its fibres are so interwoven with one another, that one stratum or layer cannot be protruded out like a slough to form a bag; but the wound will either quickly heal, or the uncut part soon burst, and so a spurious aneurism must be formed.

As for the innermost coat, if it were left alone uncut, it would either soon burst and form a spurious aneurism; or if it kept entire and gave way to dis-

*by the
Distipation
of its most
fluid parts,*

LECT. III. tion, it would in time form a round bag with a narrow neck. But as far as I know, no such tumor was ever observed to follow upon the wound of an artery.

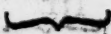
As therefore the aneurism, that is caused by the wound of an artery, is always of the spurious kind, and consequently the tumor always extravasated blood, compacted and hardened, there is no cure for it but the operation; which, when it is in the arm, occasioned by a prick of a lancet, should always be boldly undertaken, without regard to the place of the bifurcation of the brachial artery, or it's splitting into the radial and cubital branches. For there are always arterial twigs sent off from the main trunk of the brachial artery above it's splitting, which anastomose with the radial and cubital branches. WINSLOW describes no less than three of them as constantly found: and therefore there is no fear of gangrene or mortification in the limb, though the wound in the artery were above the bifurcation of the main trunk, or as high as it ever can be cut by a surgeon attempting to open a vein in the arm. It is amazing that surgeons have so little attended to this, and have suffered themselves to be so long frightened by a bugbear. A mortification of the limb never supervenes upon the operation of the aneurism, if the surgeon hath done his part aright, at least never for want of arterial blood to nourish it.

x unless
perhaps, if
it is applied
the instrument
after the
wound is
made in the
Artery.

Compression in this case signifies nothing, as it neither can drive back the extravasated blood into the artery, nor heal the open orifice. The limb will be much sooner gangrened by the compression, than any salutary effect be brought about that way.

The true species of aneurism is a straining or dilatation of the coats of the artery without a breach or effusion of blood.

It happens most frequently where the blood impinges with the greatest force upon the sides of the artery.

artery. And therefore Dr. DOUGLASS * observes, L E C T. there are more true aneurisms formed in the arch III. of the aorta, than in all the other parts of the  body taken together.

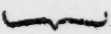
From the consideration of the nature of the innermost coat of the arteries, I am tempted to think that the destruction of that coat precedes and paves the way to every true aneurism; as it serves to prevent the blood from separating the fibres of the muscular coat from their cohesion, and their intertexture with one another.

That præter-natural distention of veins which answers to aneurism in arteries, is termed varix. If Varix. such a distention is made suddenly, it is attended with pain, as when hæmorrhoids or piles are first brought on, by straining for a stool; these being only varices of the hæmorrhoidal veins about the verge of the anus.

Varix is always occasioned by compression of some kind or other, creating obstruction to the progress of blood through the compressed vein.

L E C T U R E IV.

History of the discovery of the circulation; proofs of it's reality; it's great usefulness in physic.

I N our last lecture we have particularly confi- L E C T. dered that part of the circulation of the blood, IV. which is performed between the left ventricle of  the heart and the right auricle, through the aorta and it's branches into these of the two venæ cavæ.

And we have, for clearness sake, anticipated so much of the intended account of respiration, and the use of the lungs, as to acquaint you that the blood circulates in the same manner through them as in the rest of the body; that is, from an artery and

* On the peritonæum.

L E C T. it's capillary branches into it's correspondent vein;
 IV. with this difference only, that respiration is necessary to effect that passage of the blood through the lungs, which being an important function, richly deserves to be considered at large in a lecture by itself.

We had in a preceding lecture explained the action of the heart, and the course of the blood through it's different parts, it's auricles, it's ventricles, and the trunks of the great vessels, that either open into it, or issue from it.

So that by this time we have had a full view of all the parts of the circulation, bating the effect of respiration on that part of it, which is performed through the lungs.

We might now pass to explain the next function, to wit, respiration; but as the circulation of the blood is so important a subject, so truly fundamental to the knowledge of the animal ~~o~~economy, and consequently to that of the nature and cure of diseases, I thought proper to bestow a particular lecture to lay before you,

1st, An account of the opinion of the ancients, concerning the uses of the heart and motion of the blood, before the circulation was discovered;

2dly, The history of the different steps that led to it's complete discovery by the immortal HARVEY;

3dly, Sufficient experimental proofs of it's truth and reality; and

Lastly, To set forth the advantages that accrued to medicine from it's discovery.

We shall speak briefly to each of these heads in order.

HIPPOCRATES, the most ancient physician, whose works we have left, believed, as appears by many passages in them, that the blood had a constant accustomed motion through the whole body. In his first book *De Morbis* he speaks " of the
 " usual

usual and constant motion of the blood." In his *Lect.* book *De Cordis* he calls "the veins and arteries the fountains of human nature; the rivers that water the whole body; and which if they be dried up, the man dies." In his treatise *De Venis* he says, "that the blood vessels, which are dispersed over the whole body, give spirits, moisture and motion, and all spring from one (vessel) and that one has no beginning, nor no end, that I can find, for where there is a circle there is no beginning."

These are a few of the clearest passages amongst many others, which VANDER LINDEN hath heaped together, to prove that HIPPOCRATES certainly knew the circulation as it is known at this day, and that HARVEY only revived it. He is followed in the same wrong-headed notion by DERELINCOURT*.

But it is plain that these are but general vague opinions, entertained rather through sagacious conjecture than any convincing proofs. And though they should be thought to shew sufficiently that he had a general knowledge of some circulation or other, it is evident they point out nothing of the particular modus thereof; and in his treatise *De Cordis*, if that is genuine, where he had an opportunity of displaying what knowledge he had of it's functions and uses, he delivers such opinions concerning them, as are quite inconsistent with the modern established doctrine. Take this for an instance, "The auricles of the heart, (says he) perform the office of bellows, to draw in air to cool it."

But further, if HIPPOCRATES had known and described the circulation, could GALEN, who understood his works so well, who studied them so closely, who probably had some of his pieces in his hands, which are now lost, or at least had correcter copies of them than we have, who was so great an admirer of the divine old man, and so

* See his annexa to the *Thesis de Lienosis*.

LET. zealous for his glory, and who was so laborious and
IV. inquisitive with respect to anatomy and physiology.

I say, could this GALEN have missed learning the true doctrine of the circulation from the works of HIPPOCRATES, if it had been contained therein? But it never was pretended that GALEN knew it. It would have been highly unreasonable so to do. For GALEN scarce ever undertakes to assign the use of any part that hath a connexion with the heart, without uttering blunders and absurdities, as shall be shewn presently.

Upon this subject PITCAIRN'S *Problema de inventoribus*, and WOTTON'S *Reflections on ancient and modern learning*, deserve to be read.

From HIPPOCRATES we pass to GALEN, whose doctrines concerning anatomy and physiology, as well as the other parts of medicine, were standards to posterity till the restoration of learning. The Greeks after him, and the Arabians and their followers, did nothing but write out and comment upon GALEN, till the sixteenth century was pretty far advanced: insomuch that it was deemed a kind of blasphemy to differ from and oppose him.

The substance of GALEN'S doctrine concerning the action of the heart, and the motion of the blood is briefly this;

That the blood contained in the veins is distributed all over the body for the nourishment of the parts.

That the right ventricle of the heart is the chief storehouse for the reception and perfection of the venous blood; which it attracts from the two *venæ cavæ*, and by it's operation and energy renders it fit for the purpose of nutrition.

That a great, if not the greatest part of the blood in the right ventricle transudes through pores or holes in the septum to the left ventricle; and the remainder passes into the lungs for their nutrition.

That

That the left ventricle draws air from the lungs, L E C T. IV.
as the right one does blood from the cavæ; which
air, together with the blood transfusing from the
right ventricle, constitutes the arterial blood, that
flows within the aorta and it's branches, and is
thinner and more spirituous than the venous blood,
being destined to convey life and natural heat to
the parts, as the venous blood does nourishment.

And lastly, that the diastole of the arteries, as
well as the expansion of the lungs in respiration,
serves to ventilate the blood, and let fuliginous
vapours transpire.

This is the most consistent view (if any con-
sistency can be said to take place amidst such ab-
surdities) of GALEN's notions concerning the heart
and motion of the blood, I have been able to make
out; and these, chimerical as they are, and built
upon no manner of experimental proof, past cur-
rent, and were even held sacred for about fourteen
centuries, none daring to think for themselves, or
so much as differ from GALEN; much less to con-
tradict or confute him.

That great, that injured name, the divine VESA-
LIUS, was the first author of note that ventured to
detect the errors of GALEN, and supply his defects
in anatomy and physiology. In the sixth book of
his immortal work *De Corporis humani Fabrica*, first
published in 1543, but by him finished somewhat
sooner, his dedication to the emperor CHARLES
the Great, bearing date August 1542, after having
set forth GALEN's account of the functions of the
heart with great accuracy, elegance and spirit, he
declares himself quite dissatisfied with it, but adds,
that he hath not hitherto been able to satisfy him-
self with respect to any other explication of these
matters to be substituted in it's stead. He gives
such reasons for his dissatisfaction, as are almost suf-
ficient to establish the circulation. We shall give you
a faithful translation of the whole passage, to shew
how

LECT. how near he was hitting the mark. "An re-
IV.

" of the heart and the uses of it's parts, I have
" chiefly adapted my discourse to the sentiments of
" GALEN; not indeed because I thought him
" every way agreeable to truth, but because I am
" as yet diffident concerning any new use that
" should be assigned to these parts, it being but
" a short space of time since I adventured in the
" least to dissent from that prince of physicians:
" But I would have students seriously to consider
" the septum or partition of the heart, or the
" right wall of the left ventricle, which is as thick
" and closely compacted as the other part of the
" heart that constitutes the left ventricle; inso-
" much that I cannot see how any blood can be
" transmitted from the right ventricle to the left
" through it's substance, especially as the vessels
" of the heart open into it's cavities with such
" wide orifices, not to mention the issuing of the
" vena cava from the heart.

" And while I think on these things, many other
" present themselves to my mind, concerning the
" course of arteries, such as that no vein goes to the
" stomach and intestines, or even the spleen with-
" out an artery attending it; and that almost the
" whole of the vena portarum hath a concomitant
" artery. Besides, there are such large arteries di-
" stributed to the kidneys, that we should by no
" means affirm their sole use to be to temper the
" heat of these parts; and yet less, that the sto-
" mach, intestines and spleen receive so wide arte-
" ries as they do, only to maintain natural heat
" there.

" Add to this, that it must be owned for many
" reasons there is a mutual flux and reflux of liquids
" in the veins and arteries; and that the weight
" or gravity of the fluids contained exerts no man-
" ner of effect within them,

" And

“And besides that the membranous valves of **THE HEART**, though they may chiefly serve for the **IV.** abovementioned purposes, yet do not altogether prevent all regrefs of matter.

“And in regard that when the heart is cut quite through transversely, in opening live animals, when it's motion is quite ceased, the auricles still palpitate; and in foetuses and new born children are so very large, who must not be convinced that they are formed for a more important use than merely for supporting the vessels?

“And likewise there is a much greater difference and unlikeness between the walls of the right and left ventricles, than between the nature of their contained fluids; not to mention the difference between the capacity of the venal artery (the pulmonary artery) and that of the aorta.

“And there are not a few things more which present themselves, and would prompt us to call in question the common opinions of anatomists; which because it would be too tedious to mention them all, and I have no inclination at present to make an innovation in part, because I am far from being clear upon the whole, I shall now put an end to the account of these parts.”

Thus far **VESALIUS**. *

Here are, gentlemen, very large strides made towards the discovery of the circulation, and reasonings worthy of so great a genius, drawn from a masterly contemplation of the frame of the parts, and from phaenomena in opening living animals, the very way that **HARVEY** took to complete that noble discovery. And it is scarce to be doubted, but that if **VESALIUS** had not been called, soon after publishing the first edition of his work, to the court of Spain, where his thoughts were otherwise employed; and where, as he complains himself, he could scarce procure a skull, he would have finished his begun pursuits, and been before hand with

our

There is a mistake here; this passage not being in the first Edition of Vesalius, which did not appear till the year 1555, 2 years after the death of Pericetus.

LECT. our countryman. His genius, his dexterity, his
IV. ardour were altogether incomparable.

However that be, this passage in the celebrated work, which was the admiration of all the sensible and judicious of the profession, and was in the hands of every body that could afford to purchase it, was like a signal for all curious enquirers into these matters to exert their faculties, and find out such uses of the heart and it's parts as removed the difficulties that so great an anatomist and physiologist had started. ~~It is amazing that authors, who treat of the history of the circulation, have so little attended to this.~~

It was not till ten years after, to wit, in the year 1553, that MICHAEL SERVETUS, a Spanish physician, famous for his heresies and tragical end, published his book, entitled *Christianismi Restitutio*. In that book, which is said to have been a virulent and blasphemous system of Arianism or Socinianism *, (for there is hardly a printed copy of it now to be found) there was a passage which clearly set forth that the blood of the right ventricle doth not pass into the left through the septum cordis, as GALEN had taught, *non per parietem cordis medium, uti vulgo creditur*, says he, but from the right ventricle into the vena arteriosa, that is the pulmonary artery, and from thence by the pulmonary vein into the left ventricle, *magno artificio*, says he, *a dextro cordis ventriculo, longo per pulmones ductu, agitur sanguis subtilis*. In other respects he follows GALEN. See this passage in DOUGLASS's Bibliographia, transcribed from WOTTON, on ancient and modern learning. But in my edition of WOTTON's treatise, which is the first, the passage is not by far so full as DOUGLASS has it. Perhaps WOTTON met with

* But by the title of some of the sections, it would appear SERVETUS was a Sabellian. See the epitome of GESNER's Bibliotheca by SIMLER and FRISIUS, in the article MICHAEL SERVETUS.

it fuller afterwards; and inserted it in the subsequent editions of his book. LECT. IV.

It is probable, that this discovery of SERVETUS did not spread much; as it was contained in a book of religious controversies, where one would little expect to find it, and which would be read chiefly by divines; especially as the whole impression was soon seized by authority and destroyed, insomuch that it is doubtful whether there is at this day one printed copy of it extant.

REALDUS COLUMBUS, professor of anatomy first at Padua, and afterwards at Rome, repeats the same opinion in his anatomical work, printed first in 1559, concerning the circulation through the lungs; he affirms himself to be the first broacher of that doctrine; and it is very probable he had neither seen nor heard any thing of the works of an heretic, who was burnt for his heresy on the other side of the Alps, and whose books were destroyed by authority.

ANDREAS CÆSALPINUS in his *Quæstiones Peripateticæ*, first printed at Venice 1571, and afterwards reprinted there with his *Quæstiones Medicæ* 1593, delivers the same doctrine concerning the circulation through the lungs, but is more particular, especially concerning the use of the valves of the heart, and concerning the pulse. He mentions the experiment of the veins swelling upon being tied up, not between the heart and the ligature, but on the other side between the ligature and the extremity; and accounts for it by asserting, that in sleep the blood moves from the arteries into the veins, and vice versa, in watching from the veins into the arteries; thus quadrating his solution to the opinion of ARISTOTLE, (for CÆSALPINUS was a most bigotted peripatetic) who maintained, that the motion of the blood resembled the tides of Euripus, going and returning frequently backwards and forwards in the same channel. Thus he makes

the

L B C T. the veins and arteries to communicate and anastomose together, and the arteries to carry blood from the heart, and the veins return it to the heart again.

HALLER'S vast reading and extensive acquaintance with every author that gave any hints in these matters, furnished him with the names of many more, who after SERVETUS were apprised of the lesser circulation, to wit, that through the lungs, before HARVEY. See his *Primæ Lineæ*, paragraph LXII, and his edition of BOERHAAVE'S *Methodus Studii Medici*, in his catalogue of authors who have wrote *De Corde*.

One would be apt to think, after so many steps made, that the whole thing was brought to light. GALEN'S doctrine is canvassed and rejected; the passage of the blood through the lungs asserted, and even in some measure it's return to the heart by the veins; and that there was little or nothing left for HARVEY to add to these discoveries, in order to complete the doctrine of the circulation.

But let us consider, that there is a wide difference betwixt having principles in our possession, and drawing the proper conclusions from them; between picking up propositions *indiscriminately*, and laying them together in order to reason from them as from premisses. Besides, these authors we have mentioned do not narrate any convincing experiments or proofs to establish the truth of their assertions. And no doubt they were looked upon as no better than mere opinions, and upon that account disregarded. For above half a century after the publication of CÆSALPINUS'S book, who went the farthest of any of them, to wit, from 1571 to 1628, the bulk of anatomists and physicians remained as much in the mist about the action of the heart, and true motion of the blood, as GALEN was; to wit, till the immortal HARVEY published his first exertion *De Motu Cordis*.

unconnectedly

In this treatise HARVEY all at once overturns LECT. IV. GALEN's theory, proposes his own new doctrine of the circulation, and proves and establishes it by incontestable arguments and experiments.

So that HARVEY may be fairly deemed the discoverer of the circulation, in as strict a sense as PYTHAGORAS is said to have invented the 47th proposition of EUCLID's Elements; or lord NEPER the Logarithms. Both these had the way paved to them by what was known before; but they only were able to draw the proper conclusions; and the case was the very same with HARVEY.

Immediately upon publishing the first essay he was attackt by several able writers, as the broacher of an heretical system. PLEMPIUS, PRIMROSE, celebrated names, and RIOLANUS, the best anatomist of that age, were amongst the number of his opposers. And this consideration is sufficient to secure the glory of the invention to him, as it puts it beyond all doubt, that the doctrine he published was new.

to oppose.

We now come to the third head we proposed to treat of, to wit, the proofs that demonstrate the reality of the circulation of the blood. In speaking on which we do not pretend to exhibit very many of them, much less all, for that would be endless. We intend only to lay before you what we judge sufficient for the purpose. We shall endeavour to establish a chain of plain propositions, which will convincingly lead to the conclusion wanted.

And first, the blood is naturally contained in two different kinds of vessels, to wit, arteries and veins.

This is evident from the testimony of our senses. We find in the human species, or in any of the more perfect kind of animals, red blood contained in two very distinct species of canals, so termed, of the difference between which we have already

E

fully

LECT. fully treated) and, except in the auricles and ventricles of the heart, no where else.

IV.  The blood in the living body is moved through these canals, the arteries and veins, progressively.

This appears plainly by the phenomena of wounds: If a large artery or a large vein is opened, blood rushes out with remarkable velocity; which is a sufficient proof that there is an intrinsic impelling force, which urges on it's progress while the vessels are entire; and microscopes afford an ocular demonstration thereof, in small animals, that have transparent vessels, as in the tail of a tadpole, or a young frog's foot.

The arteries and veins communicate some how together.

This likewise appears from the phenomena of wounds: Open either a large vein or a large artery, no matter which, in a living animal; the animal will lose such a quantity of blood, as remarkably to evacuate both the arterial and venous systems. Another convincing proof of the communication of veins and arteries is furnished by what we find upon the injection of warm water into a large artery; it will make it's way into the corresponding veins almost all over the body.

The blood in the arteries moves from the heart towards the extremities and surface of the body.

This is demonstrated by the effects of ligature upon the arteries. In the amputation of a leg or arm, a compression must be made upon the principal artery, between the place of amputation and the heart, to prevent an hemorrhage, after the artery is cut through, and the limb taken off. And if the compression is slackened after amputation, the blood will burst rapidly out of the artery in such a direction, as plainly shews that the propelling force acts from the heart forwards.

The blood moves in the veins from the surface or extremities of the body towards the heart, and

in a direction contrary to, and retrograde from, that LECT.
IV.
in the arteries.

This follows from what appears in tying up a vein, in order to perform the common operation of blood-letting. The vein swells between the ligature and the extremity, and when it is opened, the flux of blood through it is promoted by chasing the vein from the extremity towards the artificial aperture.

A collateral proof, no less strong, is drawn from the valves of the veins, which admit the progressive motion of a fluid in them only the way we have mentioned, to wit, towards the heart, and not the contrary one; as anatomists well know, who find that veins furnished with valves cannot be filled by an injection thrown into the vena cava from the heart towards it's small branches, whereas the whole arterial system may be filled by an injection into the beginning of the aorta.

It then appears, that the blood flows in the arteries from the heart, towards the surface or extremities of the body; and the contrary way in the veins, to wit, from the surface and extremities towards the heart.

And that there is a communication between the arteries and the veins.

Therefore the blood thrown into the aorta and it's branches must return to the heart by the veins.

For the veins can receive the blood from no other source than from the arteries, as there is no blood contained in any other vessels in the body, setting aside the auricles and ventricles of the heart; but the heart is at a distance from the termination of the arteries and beginning of the veins, and therefore here is out of the question.

But a plain experiment, we have already mentioned, puts this matter out of all doubt. Water thrown into any remarkable artery, suppose the subclavian, will visibly return by the subclavian vein.

LECT. The question is now reduced to this point: How
 IV. is the left ventricle supplied with blood, to furnish
 out a fresh quantity every pulsation, to the aorta
 and it's branches?

We have seen that there is a patent passage from the conflux of the two venæ cavæ into the right auricle and ventricle of the heart; and that there is a patent passage from the right ventricle into the pulmonary artery and lungs; and that there is a septum or partition between the two ventricles, through which nothing can pass, any more than through the walls of the heart itself; therefore the blood cannot pass this way from the one ventricle to the other.

It remains, therefore, that the blood must pass out of the right ventricle into the pulmonary artery, there being no other way, unless the parts should burst.

But the pulmonary artery and it's branches lead to the pulmonary vein, and into no other path, as injections shew.

And the pulmonary vein opens into the left auricle and ventricle, and therefore the left ventricle is supplied this way, and no other.

To contract the proofs into a compendious view: The blood in the living body constantly moves in a progressive motion through the arteries and the veins, but in different and opposite directions: In the arteries from the heart forwards, in the veins back towards the heart: therefore the arterial blood must be taken up by the veins, there being no other source, from which the veins can be supplied with blood, at a distance from the heart.

When the blood comes by the veins into the right ventricle, it cannot pass out of that immediately into the left ventricle, upon the account of the impervious septum between them.

It cannot get back into the veins, the current of the blood through them, and the resistance of the valves, being against such a direction of course.

Therefore

DISCOVERY OF THE CIRCULATION.

53

Therefore there is no way left for it to pass but into the pulmonary artery; and that passage is wide and open. LECT. IV.

From the pulmonary artery there is no way but through it's small branches, into the pulmonary vein; and from thence into the left auricle and ventricle:

And thus the left ventricle is supplied afresh with blood every pulsation; and the circulation of the blood carried on in the manner we have described.

This chain of arguments is to me sufficiently demonstrative of the circulation of the blood, as discovered by the immortal HARVEY. But let students carefully read and digest his own book, where they will find the doctrine delivered and established with great candour, clearness, and strength of reason. The two letters of WALÆUS, *De motu sanguinis* and *De motu chyli*, which are subjoined to all the editions of BARTHOLINE'S Anatomy, are likewise worthy of perusal, as they contain many experimental proofs of HARVEY'S discovery.

We come now to the fourth and last head we proposed to speak to; namely, the use and importance of the doctrine of the circulation.

A few words may be sufficient to evince this. The circulation of the blood is the fundamental function in the living animal body. It is even life itself; upon it all the other functions depend, and are regulated by it's *modus* or manner.

And as the knowledge of the functions of the body in health, is the foundation of the rational doctrine of diseases, which arise only from that state of the body, which deviates from a healthy state, so our knowledge of the nature of diseases, and consequently of their rational curative indications, must needs be extremely improved by

LECT. our thoroughly understanding that fundamental
IV. function.

The ancients, who were ignorant of the circulation, went indeed great lengths by accurate observations of the signs and symptoms of diseases; of their manifest causes; of their course and termination; and of the *juvantia* and *ledentia* in different diseases, and in the different stages of the same disease: and it must be owned, that this is by far the greatest part of medicine.

But a knowledge of the animal œconomy, the foundation of which is the doctrine of the circulation, throws a wonderful light on the other parts. True theory in every science or art is both the most solid, and the most expeditious introduction into the right practical part.

The theory of the ancients was perplexed and incoherent, because it was false: and therefore both difficult to be learned, and hard to be retained; and even when learned and retained, did not carry along with it such light and conviction, as it would have done, had it been built upon truth.

If it should be objected that, notwithstanding our knowledge of the circulation, authors are still framing and broaching false hypotheses, both in the theory and practice of physic; I shall own the charge. The human understanding, even in the ablest men, is imperfect and limited; and many mix in learned and intricate controversies, who are very ill qualified to judge of and decide in them.

But as every doctrine in medicine must be rejected, which clashes with the doctrine of the circulation; if we were not possessed of such a touchstone, should we not be daily pestered with many more and wilder schemes and hypotheses than we now are, in this scribbling age; in which, notwithstanding the vast improvement of every branch of
natural

natural knowledge, scepticism, and quackery, are so triumphant; I say if, for all our advancement in knowledge, matters are so bad with us, would they not be infinitely worse, if we were less enlightened?

LECTURE V.

Of the pulse, and SOLANO's discoveries concerning it.

IN a former lecture, (to wit, the last save one) LECT. V. when treating of the motion of the blood through the arteries into the veins, we described and accounted for the pulse or beating of the arteries.

We found the reason of it to be, that the blood is thrown into them by a quick, strong effort of the left ventricle of the heart; that it moves in them from larger canals into smaller, whereby the resistance is increased as it goes on, and in their capillary terminations is the greatest of all; that upon the account of this resistance, the arteries are distended, as they are in their own nature distensible; and that their conical or tapering figure, in the larger ones at least, contributes somewhat to their distension.

This distension or diastole of the arteries, when the distending cause ceases, that is, when there is no more blood to be thrown into them, *pro hac vice*, from the left ventricle, must be succeeded by a contraction or systole, because the arteries have a power of restoring themselves, partly by their elasticity, and partly by their muscular contraction, though, as I said, much more by the former property than by the latter; by which contraction the blood is urged on into the venous system; the semilunar valves at the mouth of the aorta hindering it's reflux into the heart.

As the principal scope of these lectures is to assist students of medicine, and as the pulse is so much

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As the principal scope of these lectures is to assist students of medicine, and as the pulse is so much

LECT. attended to in practice, we have thought proper to bestow a whole lecture upon it with a practical view.

As life depends on the existence of the circulation, so health depends on it's due strength and regularity; and there being some arteries in the body so large and so near the surface, as that their manner of beating may be distinctly perceived by the touch, and many minute differences distinguished therein, (you perceive I mean the arteries of the wrists) physicians in all ages, of which we have any account, have examined the pulse at the wrist by the touch, in order to judge of the state of the sick; especially in acute distempers.

HIPPOCRATES indeed seems to have attended but very little to it; and scarce laid any stress on his observations concerning it. He mentions it but in two or three places of his works, and there only briefly. And this, we may observe by the by, is a convincing proof that he was ignorant of the circulation.

But he was so great a master of other signs, that he stood in less need of the art of judging by the pulse, than the rest of the profession, who were not so accurate observers: a strict attention to the different manner of respiration seems to have supplied that defect in him.

HEROPHILUS, about two hundred years after HIPPOCRATES, was the first who considered the pulse with accuracy, and wrote elaborate treatises upon it, which are lost.

In CELSUS's time, who flourished about an hundred years after HEROPHILUS, we find the pulse was very much consulted and attended to. *Venis maxime credimus, faith he, fallacissimæ rei.*

GALEN, who lived about a century and a half after CELSUS (the former being supposed to have flourished in the reigns of AUGUSTUS and TIBERIUS, and the latter we are sure lived about the middle of the second century after CHRIST) I say

GALEN

GALEN wrote most laboriously and voluminously L E C T. V.
upon the pulse, so as to be quite tiresome; he multi-
plies the species of pulses much more than is neces-
sary, and even seems to make distinctions where
there is no difference. He values himself on being
the first who firmly established the doctrine of the
pulse, and reduced it into a regular system; having
found many faults with what HEROPHILUS, whose
books he had read, delivered upon that subject.

Ever since GALEN's time the pulse hath been
much considered by physicians in all ages and coun-
tries; and I believe too much; that is, so much
stress hath been laid on conclusions drawn from it,
that other signs have been too much neglected.

We shall here deliver the general foundations of
the doctrine of the pulse, with that brevity which
the present course of lectures requires, referring
you to writers of institutions of medicine for a
more minute detail.

In the first place let it be attentively considered,
that the younger the person is, the pulse in health
is the quicker. In infants it is so quick, that it's
beats can hardly be numbered. As one advances
in years, it grows slower, and in extreme old age it
is naturally the slowest of all.

According to Sir JOHN FLOYER's observations,
who hath taken the greatest pains in this matter of
any author I know, the number of pulses of chil-
dren in health runs from seventy to a hundred in a
minute; in youth, from sixty-five to ninety; in
extreme old age they may be no more than sixty,
which is the slowest healthy pulse he hath observed.

2dly, The pulse varies much in different constituti-
ons. Thus in FLOYER's tables there are found in dif-
ferent persons of the same or nearly the same age,
the odds of fifteen or eighteen beats in a minute.
But I fear this variation is taken too wide.

3dly, The pulse differs according to the time of
the year, and time of the day, it being quicker
and

and varying **L E C T.** and higher in the evening than in the forenoon; according to the fulness or emptiness of the stomach; and according to rest and exercise. In general the pulse is quickened and raised by heat, exercise, fulness of the stomach, high meats and strong drinks; and is lower and rendered slower by opposite causes. Every sudden passion quickens the pulse.

Hence Celsus had good reason to call the pulse *fallacissima res*. And the practitioner ought always to make allowance for the diversity of these circumstances I have mentioned; and likewise not lose sight altogether of other signs about the patient besides the pulse.

From what hath been said, it may be observed, that the surest conclusions are for the most part to be drawn from the pulse, not considered absolutely, but relatively; that is, from a morbid pulse compared with itself when in a sound state, or with itself at different times in the same disease.

But practitioners can in a general way find that a pulse is disordered, though they have not felt the same person's pulse before, if it deviate very much from the common standard. A healthy pulse in a grown up person, in our climate, runs about seventy beats in a minute, a small matter over or under.

and The chief differences of pulses consist in different strength ^{or} weakness, greatness or fulness, and smallness; quickness and slowness; equality or inequality.

That pulse which is strong, full, equal, and slow at the same time, is the best pulse of all; and it's contrary the worst; to wit, a weak, small, quick, and unequal pulse, especially if it intermits, which is the worst kind of inequality. And a pulse is better or worse, the more it partakes of the good or bad qualities we have just now specified; and the higher the degree of these qualities is.

But let us always keep this maxim in view, to L E C T. V.
 wit, that that is a commendable pulse, which nearly
 approaches to the standard which is natural to the
 person we are treating.

And *vice versa*, that kind of pulse is in a general way so much the worse, the more it recedes from the natural pulse.

But as to the particular conclusions, that are to be drawn from the different phænomena of the pulse in particular distempers, these are to be learned from writers on the institutions and practice of physic.

GALEN, as I have said, hath wrote very elaborately and voluminously on the pulse, insomuch that few can have patience enough to read him through-out. His treatises upon that subject are so much the more tiresome, as his theory is stark naught, through his ignorance of the circulation; and yet he throws it out with as much confidence, as if it amounted to demonstration; which is GALEN's great, and I may almost say, unpardonable fault.

What PROSPER ALPINUS, in his celebrated books *De Prasagienda Vita & Morte*, delivers concerning the pulse, may be looked upon as no bad epitome of GALEN's doctrine of the pulse.

And BOERHAAVE in his Institutions gives you in a page or two the whole substance of what the ancients knew of the pulse, with his usual clearness and pithiness. His own commentary on that chapter published by HALLER, though short, is sufficient to clear up what may appear to the beginner difficult in the text, through it's conciseness.

But a very considerable improvement and enlargement of the doctrine of the pulse hath been published to the world within these twenty-five years last past, I may say since the year 1737, at which time Dr. NIHELL's book, of which more by and by, was first published.

FRANCIS

+ this refers
 to the year
 1752 when
 these Lectures
 were read.

LECT. FRANCIS SOLANO DE LUQUE, a physician of Antequera in Spain, of very moderate learning, but a
 V. very accurate and nice observer of the pulse, having made very important discoveries in that way, published them in a large volume in Spanish, entitled *Lapis Lidius Apollinis*, but so covered by, and as it were buried amidst other things little relative thereto, that no notice was taken of them, at least by physicians of other countries, for some time.

At length the very learned and ingenious Dr. JAMES NIELL, who was then physician to the English factory at Cadiz, after perusing carefully this book, and being struck with the wonderful prognostics contained therein, was excited by a laudable curiosity to go to Antequera to converse with Dr. SOLANO, in order to be thoroughly satisfied of the truth of his doctrine; and, after staying two months with him, returned fully informed and convinced thereof; and published a most accurate and distinct account of every thing relating thereto. Which book of Dr. NIELL's hath now bore a second edition.

As the historical truth of the facts is put beyond all manner of doubt, they being vouched both by the principal people of the places where they happened, and even by physicians, who, though at first of a different opinion from SOLANO, yet were at length convinced of their own errors, and so candid as to attest it under their hands; I thought it would be an undertaking both agreeable and useful in the republic of medicine to shew that SOLANO's doctrine is likewise conformable to the known laws of the animal oeconomy. And as I flatter myself I have succeeded in my design, I have drawn up and published a short treatise in Latin on that particular subject, the substance of which I here lay before you.

The discoveries of SOLANO, we are to treat of, LECT. V.
are as follows.

1st, That kind of pulse, which the ancients called *dierotos*, that is *bis feriens*, striking double, which Dr. NIHELL terms the rebounding pulse, but I think may be as fitly called the double pulse, that being a plainer appellation, SOLANO hath observed often to presage critical hemorrhages by the nose in acute distempers; and that these hemorrhages are the nearer at hand, the more frequently the double stroke recurs amidst the other regular pulsations; and the quantity of the effusion of blood will be the greater, the more the second beat exceeds the first (in the double pulse) with respect to strength and vigour.

2dly, That the intermitting pulse in like manner portends critical diarrheas, which will be the more copious, either as to the number or quantity of the stools, the greater the intermission or stop is.

3dly, That a particular kind of pulse, which he is I believe the first observer of, and calls by an out of the way name, *pulsus inciduus*, (Dr. NIHELL terms it the unequally rising pulse) portends critical sweats. In this kind of pulse there are sometimes two strokes, sometimes three, and sometimes four joined together. It's peculiarity is, that every preceding stroke rises above that immediately preceding in strength and fulness; so that if there are four such joined together, the second rises above the first, the third above the second, and the fourth above the third. SOLANO never observed above four such beats joined together. This kind of pulse, as I have said, SOLANO discovered to foretel critical sweats; which always come on the more plentifully, the greater number of such strokes is joined together, and the more each following stroke exceeds that immediately preceding in strength and fulness.

This is the substance of SOLANO's discoveries concerning prognostics from the pulse, which,

as

L E C T. as they are certainly true in fact, we shall now endeavour to account for according to the established rules of the animal oeconomy.

V. That what I am going to lay before you may be the plainer and clearer, I shall premise the following undoubted truth, to wit, that the living animal body is so wonderfully made, as not only to perform it's manifold functions aright, while in health; but when out of order, endeavours to rectify what is amiss, and throw off what is noxious, by the most commodious and effectual means that it's organs are capable of bringing about; unlike in this, as well as in numberless other respects, to artificial machines, which, when they are hurt or impaired in any part, cannot set themselves to rights, but, continuing their motions with a blind mechanical impulse, go on spoiling and destroying themselves more and more.

No mortal was ever more deeply acquainted with this truth than the divine old man, who in many places of his works speaks of nature as sufficient in all things for animals; as a principle that, without being taught, knows and executes every thing necessary for their preservation; and he has many other expressions to the same purpose.

And the more extensive our knowledge of the animal oeconomy is, the more numerous instances of this truth present themselves. We shall here only mention a few.

When any acrid or rough particle falls into the eye, immediately the orbicularis palpebrarum muscle is convulsed, and tears squeezed out in abundance; by which the noxious matter is diluted, if it can be diluted; and if it cannot, it is set a float, that it may be dislodged; and either shoved towards the lachrymal caruncle, where it may be more easily born; or taken out. In like manner, if any thing offends the olfactory nerve, it is thrown off by sneezing, the most effectual way of getting

+ palpebrarum

getting rid of it. But all this is done not only without L E C T. the direction of the sufferer, but even against his will. V.

A plain countryman will sneeze as heartily upon taking hellebore, as the best anatomist. Whatever is offensive to the stomach in a certain degree is thrown up by vomiting; what is troublesome to the intestines is discharged by stool. When the mass of blood and the juices derived from thence are changed in such a manner, as not to flow freely enough through the capillary vessels, so as that the functions of health may go on aright, a fever is raised; by means whereof the noxious matter is concocted and rendered fluxile, and fit to be expelled out of the habit by sweat, urine, stool or otherwise. In short, we may with SYDENHAM pronounce disease in general to be nothing else but an effort of nature attempting every thing in it's power, in order to expel the morbid matter out of the body, for the safety and recovery of the diseased person.

This maxim being laid down, let us apply it to the accounting for SOLANO's observations from the laws of the animal œconomy. And let us first consider the *pulsus dirotus*, or double pulse.

In this kind of pulse, the second beat follows the first so rapidly and quickly, that the least imaginable interval can be perceived between the two strokes. Now I contend, that a pulse of this kind is the most commodious and effectual way of bursting vessels that can be brought about by causes acting within the body, and therefore when we perceive that nature hath excited that effort, it as rationally portends an hemorrhage, as any other cause beginning and persevering portends it's effect.

For, by this kind of pulse, the arteries being dilated by the first stroke, are again urged so quickly by the second, as not to have time to recover their cohesion, by repeating the close contacts of their particles between the two strokes. The second stroke takes it's cohesion at a disadvantage, when it is giving way, and nearer being broke, than it is in

LECT. in the common regular way of beating, in which
 V. the artery is left at it's freedom to restore itself to
 it's narrowest dimensions, before it is again dilated.

Let us illustrate the thing by an easy example. Suppose a wall was to be beaten down by a battering ram, after the manner of the ancients. If one stroke of the machine should be so quickly repeated after another, as that the least perceivable interval of time intervened between them, would not the wall be demolished by much fewer strokes so redoubled, than if they were made at such a distance of time from each other, as that the wall, which gave some way by the first shock, might recover it's perpendicular posture, and the stones and mortar in some measure regain their cohesion?

In like manner it is plain, that a few double strokes of the *pulsus dierotus* will have a greater effect to burst small arteries, than a great number of regular strokes of equal strength.

And it is no less evident, that the more frequently the double beat recurs amongst the other regular pulses, the hemorrhage will be the sooner brought on; because thereby the chances of bursting the vessels will be multiplied.

Further, as it is the second stroke that finishes the rupture, it follows, that the more the second stroke exceeds the first in strength, the more plentiful the hemorrhage must be; as more numerous vessels must be broke thereby, and the rupture and laceration made wider; which perfectly tallies with SOLANO's observations.

If it should be asked, why this double pulse should prognosticate an hemorrhage by the nose, rather than any other, my answer is ready. The small arteries spread upon the *membrana Schneideriana* in the cavity of the nose, are propagated pretty directly from the heart, springing from the external carotids; and therefore sustain a pretty strong impulse from the heart; and besides, are exposed to the

the open air, and therefore want a support which L E C T. V.
 other arteries have, that are buried amidst conti-
 guous solid parts. Add to this, that when these
 arteries are strained and molested, a sneezing some-
 times is brought on, through irritation of the
 nerves, which strongly co-operates with the original
 cause, to bring about a rupture of them. Upon which
 account hemorrhages by the nose, (if we except
 the menstrual discharges of the sex, which are
 brought on not by a rupture, but a dilatation of ves-
 sels) are both the most frequent, and the most co-
 pious of any in the human body.

So that the whole amounts to this, that when
 the animal machine is out of order, and when the
 most effectual relief, that could be administered to it,
 would be a breach of the vessels in the nose, nature
 makes use of the most proper means of accom-
 plishing that breach, to wit, by exciting the double
 pulse; which is the most effectual way, the *modus*
unicus of producing that effect.

Nor is this to be more wondered at, than that
 the eye waters when any sharp or rough particle
 gets into it; or that sneezing is excited by any
 irritating powders being drawn up ^{into} the nostrils;
 these are neither less ingenious contrivances, nor
 less intricate in their natures, than that which we
 have now explained, though they are more usual,
 and therefore less astonishing.

We come next to consider the second article of
 SOLANO's discoveries, to wit, the presages to be
 drawn from the intermitting pulse. This kind of
 pulse, as we have already mentioned, he found to
 portend critical diarrheas in acute distempers;
 and to denote that they will be the more copious, the
 longer the intermission or stop is perceived between
 one beat and the next.

We hope to shew, that this prognostic is no less
 rational and agreeable to the laws of the animal œco-
 nomy, than what we have just now been treating of.

LECT. But let us previously take into consideration the nature and causes of the intermitting pulse.

V. If, immediately upon the back of one contraction or systole of the arterial system, the venous blood is not sent quickly enough, and in sufficient quantity, into the right sinus and auricle of the heart, so as to fill and distend them enough; and effectually irritate them into contraction, and make them throw their blood into the right ventricle in the usual time and rithmus, then the pulse must stop for a space, and become intermitting: for if the right ventricle is longer than usual in filling, the passage of the blood through the lungs must be delayed, and consequently the supply of the blood to the left ventricle must be put off, and so the next diastole of the arterial system must be so much the longer in returning.

This being duly considered, let us apply it to SOLANO's prognostic drawn from the intermitting pulse.

While nature is bringing about critical diarrheas in distempers, if the pulse is upon that account anywise remarkably changed, it must be into the intermitting kind; upon the account of the secession of serous matter, of which loose stools consist, from sanguiferous vessels into the lateral canals, which convey it into the ample cavity of the intestinal tube.

By which means the vessels that contain red blood will be in some measure emptied, and drained of their usual quantity of liquids; and so the right sinus and auricle will not be speedily enough filled and irritated into contraction; and all the other consequences I have just now mentioned will follow.

It will likewise follow, that the greater quantity of the matter of a diarrhea is carried off by lateral serous vessels into the cavity of the intestines, the more the vessels that carry red blood will be emptied,

emptied, and drained of their proportion of fluids; and therefore the stop of the pulse will be the longer. And consequently, the greater the intermission is between the two beats of the artery, the more copious a diarrhea is prognosticated; which exquisitely agrees with SOLANO's observations. LECT. V.

But here we must, with Dr. NIELL, distinguish properly, and limit SOLANO, who upon this head hath made his conclusion too general. As every kind of intermitting pulse is not occasioned by a secession of serous matter towards the bowels, so a diarrhea is not always prognosticated by an intermitting pulse, though it often is; and therefore other circumstances in the patient's condition are to be taken in, and carefully considered and weighed.

We are now come to the third and last article of SOLANO's discoveries, to wit, his prognostics taken from the *pulsus inciduus*, as he calls it, and which NIELL calls the unequally rising pulse. I think it may be called simply *pulsus ascendens*, the ascending pulse.

In this kind of pulse, as I have said before, every stroke rises above the one immediately preceding, in strength and fulness. SOLANO found sometimes only two beats of this kind joined together, sometimes three, and sometimes four; but never observed any greater number.

He found that this kind of pulse, if it was soft, was in acute diseases a most certain forerunner of a critical sweat; and that the sweat preceded by it is always the more copious, the greater the number of such strokes joined together is, and the more each following stroke rises above that immediately preceding it in strength and fulness.

He says likewise, that he always found that kind of pulse soft, except in one instance, in which it being hard, he taking other signs about the patient into consideration, prognosticated a critical jaundice, which came on as he had foretold.

LECT.

V.

The rationale of this prognostic is not more difficult, than that of the other kinds we have explained. The efforts of the heart and arteries, which constitute this pulse, are as exquisitely adapted to excite a sweat, as the *pulsus dicrotus* is to effect a breach of the small arteries of the nose. For let us suppose in an acute distemper, the morbid matter concocted and rendered fluxile, the crisis now near, and the pulse soft, by what other imaginable method can a sweat be more effectually raised, than by such a pulse as we have been describing? By each stroke rising above another in vigour, the small cutaneous arteries, which convey the matter of sweat, must be farther and farther opened and dilated, the fluids being projected farther and farther within them, till at last their extremities exhaling into the surface of the skin be quite opened, and the sweat break out. And it is likewise evident, that the greater number of these strokes rising above each other is joined together, and the more they exceed each other in strength and fulness, the sweat will be the more copious. As the growing tide with every wave rising above that immediately preceding rolls the flood over larger and larger spaces of the sandy shore; so the ascending pulse propels the concocted fluxile serum farther and farther into the minute cutaneous serous vessels, till at length their extremities are completely opened in the surface of the skin; after which the canals being moistened and relaxed, the common regular pulse is sufficient to keep up the sweat, while it's matter continues to be supplied.

Thus we have shewn, that there is a relation founded in the known laws of the animal œconomy subsisting between the signs and the things signified in these new observations of SOLANO's concerning the pulse; which are the greatest addition to, or improvement of, the general doctrine of signs, that medicine can boast of since the days of HIPPOCRATES.

And

And therefore every practitioner should make himself acquainted with them, and carefully peruse and digest Dr. Nihell's book. Very often one gains more credit by lucky predictions, than by the most regular and successful cures.

LECTURE VI.

Of respiration.

WE have seen what life is, and wherein it consists, to wit, in the action of the heart, and the motion of the blood caused by that action. LECT. VI.

We have particularly and minutely described both these; and have traced the blood in it's course through the auricles and ventricles of the heart into the aorta and it's branches; and from thence through the veins back again to the heart.

But though this motion of the blood constitutes life, infomuch that wherever that is, there we pronounce life to be; yet, as we observed in the beginning, ~~any~~ degree of life would quickly be at an end, if there was no other animal function added to it. And the function most immediately connected with that life, and most requisite to support it's duration, we shewed to be respiration. This we are at present to take into consideration, and explain it's nature, instruments and effects.

RESPIRATION is the alternate drawing and expelling air into and out of the lungs, whereby their cavity and volume, and that of the thorax or chest in which they are placed, is alternately enlarged and diminished.

That the nature and circumstances of this function may be the more clearly understood, it will be necessary to premise a brief account of the structure, first of the thorax, and next of the lungs.

The thorax is a large cavity, somewhat in the shape of a cone, reaching from the under part of

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LECT. the neck to the abdomen or lower belly, from
 VI. which it is divided by the diaphragm. The bones
 that form and guard it's cavity, are the twelve
 vertebræ of the back behind, twelve ribs on each
 side, and the sternum or breast bone before. As the
 diaphragm, which parts it from the abdomen, is
 not horizontal, but slanting downwards and back-
 wards, it's cavity is considerably shorter before
 than behind. The ribs, which form and guard the
 greatest part of the cavity of the thorax, are all
 articulated with their respective vertebræ, in such
 a manner as to admit of a motion upwards and
 downwards, with some degree of rotation at their
 insertion, like the motion of the ball and socket.
 They are likewise all, except the twelfth or lower-
 most, connected and articulated with the sternum
 or breast bone, by the intervention of cartilages, so
 as to admit of the same motion, to wit, upwards
 and downwards.

The ribs are all more or less arched, being convex
 outwardly and concave inwardly towards the cavity
 of the thorax. The first and uppermost is the most
 crooked of them all, and it's position is most at
 right angles with the spine; and therefore, when the
 spine is erect, it lies almost horizontally. The ribs
 as they descend grow each gradually longer, than
 those above to the seventh; and they all become
 more oblique in their direction towards the sternum.
 From which structure it follows, that if the ribs
 are all moved upwards round their articulation
 with the vertebræ, their arched middle parts will
 be pushed outwards and laterally, and the ster-
 num, to which they are joined, outwards and for-
 wards; and consequently, the cavity of the thorax
 will be widened and enlarged.

But there is a set of muscles that perform this
 office, to wit, the intercostals both external and
 internal. They run obliquely from the edges of
 every rib, to those of the ribs nearest each other,

for the whole length of the ribs; and from the highest rib to the lowest. The fibres of the external have a direction contrary to that of the internal, by which contrivance their joint action becomes the more steady, the ribs being pulled in the diagonal of these two directions; that is, neither forwards nor backwards, but directly towards one another; so far are they from antagonising one another, as some physiologists have taught. Dr. HOADLY hath given beautiful and accurate figures of them in his book on respiration. LECT. VI.

When these muscles act, they endeavour, as I have said, to pull the ribs nearer one another; but as the ribs are gradually the more moveable the lower they are, the first and uppermost having scarce any motion at all, by their joint action the whole system of the ribs (except the twelfth or lowermost, which is fastened to the diaphragm, and therefore follows it's motion) is lifted upwards, and the cavity of the thorax widened and enlarged, in the manner I have said.

This widening of the thorax any one may experience in his own body. Apply a fillet or garter round the broadest part of the chest, and immediately after expiration observe the exact measure; then draw in your breath strongly, and you will find that a longer line will be required to go round than before, by an inch or more in a middle-size.

But there is another contrivance to enlarge the cavity of the thorax, to wit, the diaphragm or midriff. This muscle, which, as I have said, divides the thorax from the abdomen, arises from the sternum before, from all the ribs on each side, from the twelfth to the seventh; and behind, from the last vertebra of the thorax and the first one or two of the loins. It's fibres run fleshy from the circumference towards the centre some way, and then become tendinous; the whole tendinous part, in the middle, in figure, somewhat resembles the

+ exclusive

LECT. figure of the ace of clubs. It hath, besides
 VI. muscular appendixes, one on each side, arising from
 the third vertebra of the loins; which proceed upwards fleshy, and are inserted in the tendinous part. The whole diaphragm, as was observed before, slaunts; it's anterior origins being remarkably higher than the posterior ones. It is not plain, but remarkably convex towards the thorax, and concave towards the abdomen; insomuch that it's middle or centre rises always higher in the thorax, than it's highest origin at the sternum.

When it acts, the fleshy fibres shortning pull the tendinous centre towards their origin, that is, downwards, thereby rendering it plainer and less convex, and so lengthens the cavity of the thorax downwards.

Here then is a double way of enlarging the capacity of the thorax; by the intercostal muscles raising the ribs it is made wider; and by the action of the diaphragm it is rendered longer, or deeper. Let us proceed to shew for what purposes this mechanism is intended.

But we must first explain the structure of the lungs.

The lungs are situated in the cavity of the thorax. They are divided into two large parts called lobes, the one on the right, the other on the left side, which are separated from one another by a production of the pleura (the membrane that lines the whole cavity of the thorax.) This production, called mediastinum, divides the thorax into two nearly equal separate cavities, that have no communication with one another; insomuch that if blood, or pus, or water is poured out into one of these, it can find no entrance into the other. But as the heart and pericardium, with the great vessels that open into it, and issue from it, are contained in the left division, upon that account the left lobe of the lungs is considerably less than the right.

* Duplication

+ Duplication

nearly

The external air finds admission into the lungs by L E C T. VI.
 the wind-pipe, called trachea or aspera arteria, the head or upper part of which, called larynx, opens into the mouth; it's opening is called glottis. It is composed of different cartilages firmly fastened together, which are furnished with proper muscles, chiefly subservient to the purposes of the voice, and likewise instrumental in swallowing.

The aspera arteria or trachea is continued to the larynx, and proceeds downwards towards the lungs. It is a firm tube, made up of cartilaginous rings, joined together by muscular fibres. These rings are incomplete backwards; probably, that it may yield there somewhat to the aliments distending the oesophagus in swallowing, that lying immediately behind the larynx, or nearly so. The whole is covered on the outside with a cellular membrane; and lined on the inside with a smooth polished one.

It descends entire into the thorax, as far as nigh the basis of the heart; and there divides into two great branches, the one right, the other left; which again are divided and subdivided into lesser and lesser ramifications; and so distributed through all the substance of the lungs, terminating at length in small membranous dilatable cells or vesicles.

The pulmonary artery, which we have had frequent occasion of mentioning before, arises from the right ventricle of the heart, proceeds towards the lungs, and, being divided and subdivided into branches gradually smaller and smaller, is distributed all over the substance of the lungs. It's smallest capillary branches become the origins of the pulmonary veins, which likewise run all over the lungs, accompanying their corresponding arteries: and at length form the great pulmonary vein; which opens into the left sinus and auricle of the heart,

But

LECT. VI. But besides these branches of the pulmonary artery that carry red blood, and transmit it to the veins to be sent back to the heart, it likewise sends off extremely small lateral serous vessels, which open into the inside of the bronchia and vesicles all along; and furnish them with a moist extreme subtle fluid, or rather vapour, which bedews their internal surfaces, hinders them from growing together, and preserves them supple and dilatable. This appears from warm water, or even a fine injection's passing from the pulmonary artery into the cavities of the bronchia. KAW mentions his having often repeated this experiment with success.

So that the lungs, besides it's external membrane, and it's cellular texture, is a congeries of air vessels, and vessels which carry blood or juices derived from blood; and these two kinds of canals are so uniformly dispersed through the lungs, that in every physical point there are branches of both all over.

Before we explain the action of respiration, we shall from natural philosophy give a short account of the properties of that fluid, which is alternately drawn into and expelled out of the lungs thereby, to wit, the air; and explain it's principal properties.

Air is a transparent, and therefore invisible fluid; (except when pretty large portions of it are inclosed in another medium, as glass or water, and then it appears white).

It is elastic, that is, when compressed it endeavours to restore itself with a force proportionable, and nearly equal to the pressure. From this property it is susceptible of tremulous motions or vibrations; and is the medium of sound.

It is heavy in a certain degree, being in proportion to water as 850 to 1, at a medium, for the weight of air varies, as appears from the phenomena of the barometer; so that if a pint of water weighs

weighs a pound, a pint of air will weigh something more than nine grains. Lect.
VI.

As it is an heavy fluid, it hath that property common to all such fluids, to wit, that it's parts are pressed every way by the weight of the column above; and the force of that pressure is in some measure in proportion to the altitude of the column. And it endeavours to recede from that pressure, and actually does recede, if there is a vacuity for it to run into.

It is compressible by a suitable force into a lesser space than it possesses in the atmosphere.

And therefore near the surface of the earth it is denser and heavier than higher up; as the column of air pressing there is higher. In this respect it is quite contrary to water, which is not compressible by any weight or force; as far as experiments have shewn. Water at the bottom of the sea is no denser, than in the surface, bating what effect a difference of cold or heat produces.

Air hath it's spring or elasticity increased by heat, and diminished by cold, and therefore heat uniformly rarefies it, as cold condenses it; and this property seems to be unlimited.

If the pressure of the atmosphere is taken off a portion of air, it expands itself into a larger space; and that property, likewise, seems to be unlimited; a cubic inch of air, when freed from the pressure of the atmosphere, will uniformly fill an indefinite space.

It's elementary parts, when separated from one another, and intimately mixed with other bodies, whether fluid or solid, exert no elasticity, unless the atmosphere is removed, or violent heat applied: or unless fermentation, putrefaction, or effervescence is produced, which sets the aerial particles at liberty. But when joined together, by any of these means, they recover that property.

These

LECT. These are the chief properties of air, considered
 VI. as pure and unmixed with any thing foreign to it's nature. But our air, the atmosphere we breath in, is a chaos of every thing that is volatile, and light enough to be suspended in it, and every thing that can be dissolved in it: and particularly, it is always more or less fraught with watery particles, as water exposed to the air hath always more or less air in it, as the air-pump shews. But still it's fundamental qualities remain, to wit, it's fluidity, weight, and elasticity or spring; though the two latter are variable in their degrees, according to the various causes that act upon it.

For the nature and properties of air, besides writers of systems of natural and experimental philosophy, consult BOERHAAVE's Chemistry in the theoretical part, ARBUTHNOT on the air, and HALES's Vegetable Statics.

Let us then suppose the cavity of the thorax to be enlarged by the action of the intercostal muscles, which widen it by pulling the ribs upwards towards the first rib, which is almost altogether fixed; and by the diaphragm, which becoming plainer, and pressing down the viscera of the abdomen, renders it's cavity longer and deeper; in this case room will be made for air to be pressed into the larynx, trachea and lungs by the atmosphere, to fill up the new space with air of the same density with the ambient air. And it will rush in with so much the greater force, and in so much the greater quantity, the more the thorax is enlarged. This air rushing in will distend the membranous vesicles of the lungs, and fill them in such a manner, as to keep the external surface of the lungs always contiguous to the pleura; for there is no air between the pleura and the external membrane of the lungs; if there were, the lungs could not play, as the air so included would absolutely counterbalance the external pressure of the atmosphere.

Now

Now by this expansion of the vesicles of the L E C T. lungs, the capillary terminations of the pulmonary V L artery, and the beginnings of the pulmonary vein, which run along these vesicles all over the substance of the lungs, are unfolded and streightened, and so create less resistance to the right ventricle of the heart, in propelling the blood through them into the pulmonary vein, and left auricle of the heart.

At the same time, the air we breath in is considerably colder than the blood in any part of our body, and particularly that of the lungs, where the velocity is very great, as also the friction; and this is the chief cause that generates heat in the living animal body: and again, as the air we breath is much colder than the blood in the lungs, it will temper and diminish it's heat, and hinder it from being excessive.

And upon this account ~~the~~ ^{an} animal, that is made remarkably like the human species, cannot live any space of time worth mentioning in air, that is not considerably colder than our blood is, at the very coldest it ever can be, consistently with life. See BOERHAAVE'S experiments upon a dog kept in an oven, heated to a certain degree, in his Theory of Chemistry.

But this is to be so understood, that there is actually heat generated, by the friction of the globules of blood passing through the capillary vessels there. But the cool air hinders that heat from becoming too great, which otherwise it would.

These are the effects of inspiration, or drawing air into the lungs; let us now consider expiration, or the expulsion of air out of them.

When there is as much air taken in as the well being of the animal requires, then the influence of the will (whatever that be) upon the muscles that widen the thorax is discontinued; the consequence whereof is, that the cartilages of the ribs, which in inspiration were in a violent state, by being pulled upwards,

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Emanation
here among
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L E C T. upwards, as they are now at liberty, will restore themselves by their elasticity, and pull down the ribs,

VI.

At the same time the muscular fibres of the bronchia, that connect the cartilaginous rings, are now at freedom to act; whereas, in inspiration, they were violently distracted. By their action they pull the rings closer to one another, and thereby diminish the volume of the lungs all over.

Besides, as in a natural state there never is, nor can be any elastic air between the outer surface of the lungs and the pleura, as hath appeared from undoubted experiments, the pressure of the atmosphere will co-operate with, and assist the elasticity of the cartilages in thrusting down the ribs.

But this is not all. For the muscles of the abdomen, all more or less, concur towards expiration, by diminishing the cavity of the abdomen, and pressing it's viscera upwards against the diaphragm, so pushing it higher up into the thorax, and shortening it's cavity.

The immediate effect of expiration, is by diminishing the volume of the lungs to force the blood through the capillary terminations of the pulmonary artery, and the venous system corresponding with them, into the left auricle of the heart.

The current of the blood through the pulmonary artery, and the semilunar valves at it's mouth, hinder it from being pressed back into the right ventricle; and determine it's progress entirely towards the left auricle.

This account of respiration is much illustrated and confirmed by an experiment of the learned and accurate KAW, in his *Perspiratio dicta Hippocrati*, &c. He injected warm water into the pulmonary artery gently, and with a continued stream; at the same time an assistant, by alternately inflating the lungs, and suffering them to collapse, imitated natural respiration. He then saw with pleasure the warm water pass expeditiously through the pulmonary artery, and it's capillary branches into the pulmonary vein,

make

make it's way into the left auricle and ventricle of **L E C T.**
the heart, and run out of the aorta. **VI.**

So that the alternate distention and collapsing of the lungs is necessary to expedite, and even to effect the trajection of the blood through them.

Were it not for this alternate change of the lungs, the circulation of the blood in the human body, and all other animals that have lungs like us, and two ventricles to their hearts, I mean animals that are born, and have for some little time used their lungs, could not be carried on; for,

If the lungs continued in a state of distention by the air's being pent up within them, that air would be heated, and have it's spring increased to such a degree, that the small blood vessels running along the membranous and vesicular texture in the lungs, would be so hard pressed by it, as to stop all passages through them; and so life, which consists in the circulation of the blood, would quickly be at an end.

On the other hand, if the lungs remained in a collapsed state, without being distended by air inspired, the small vessels would be folded together like threads in a clue; so that the right ventricle could not force the blood through them so expeditiously, as that one pulse should regularly succeed another. The blood would quickly stagnate in the right sinus, auricle and ventricle, and death ensue.

As therefore the expansion and constriction of the lungs, that is, inspiration and expiration, must be alternately influenced for the continuation of life, the necessity of the thing is a sufficient reason for it's being so; and supersedes other ingenious solutions of this important phænomenon.

The whole matter, as far as we are like to know it, and as far as we are concerned to know it, in order to be the better practitioners, amounts to this. As soon as there is by inspiration air enough admitted to answer the purpose of the trajection of the blood through the lungs, the animal for self-preservation, and

LECT. and to avoid uneasiness, drops inspiratory efforts,
 VI. and commences those of expiration; and when it
 hath performed them in a proper degree, it again
 inspires, and so on.

It is furnished with organs to do all this easily; and by habit it performs them without any seeming influence of the will, and even while asleep.

And the whole must be resolved ultimately into the laws, according to which the sentient principle presides over the vital motions in the body, in such a manner, as that for self-preservation, and to avoid pain and death, they are carried on aright, while the state of the organs and fluids will permit.

So that there is no need of any hypotheses, of the compression of particular nerves, or of an interrupted secretion of spirits, to account for the action of the different sets of muscles, that contract, or dilute the thorax, at one point of time more than another.

The most important general uses of respiration are to effect the trajection of the blood through the lungs, and so complete the circulation, in which life consists. For without it, as we have shewn, this trajection could not take place in animals, that have lungs like us, after they have breathed, and used them some little time. Foetuses, that are pent up within the uterus, live under another kind of circulation, which we shall explain in it's place.

By this trajection of the blood through the minute vessels of the lungs, with such a velocity as it must there have, it is comminuted, and divided; it's globules are compacted, condensed, and rounded; and so rendered the fitter for flowing commodiously through the other canals of the body, for yielding the necessary secretions, and answering the numerous purposes of the animal œconomy.

By it heat is generated in the animal body, through the attrition the globules of blood create against the minutest pulmonary arteries: not indeed solely, because

cause the like attrition, it meets with in the capillary branches of the aorta, no doubt contributes it's share. LECT. VI.

By it the redness of the blood is brought on. The chyle is white, and the lymph is pellucid; but the mass of blood, after it hath past the lungs, is red. It would seem, from Sir ISAAC NEWTON's discoveries concerning colours, that the change of colour here is owing to the increase of density. But no doubt besides respiration, the circulation through the minutest extremities of the aorta contributes somewhat towards this increase, and therefore enhances the red colour of the blood.

To bring about these ends, all the blood of the body is propelled some time or other through the lungs; which cannot be truly said of any other viscus of the body.

And in the same time, that any quantity of blood hath circulated from the mouth of the aorta through it's capillary branches, and returned to the heart, an equal quantity of blood hath past through the lungs.

It hath been matter of much dispute, whether by means of respiration air gets into the small pulmonary vessels, and is mixed with the blood, or not.

There are very strong reasons to believe it does not. Air doth not pierce through wet leather or bladders, as the experiments made by the air-pump shew, where valves made of wet leather or bladder effectually keep out all air, otherwise the experiments could not succeed.

It cannot get into the blood vessels, by penetrating through their walls, otherwise it would likewise be able to make it's escape through the membrane of the lungs, and place itself between their external surface and the pleura, which we are certain is not the case; for then the lungs could not play.

And it is ~~altogether impossible~~, that it should get into the extremities of the minute lateral canals, that open into the cavities of the bronchia and vesicles;

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their

* highly
improbable

LECT. their minuteness, and especially their moisture, seem
VI. a sufficient guard against that.

~~~~~ Air gets another way into the blood ; to wit, by being intimately mixed with our aliments, and passing into the lacteals with the chyle ; but it's particles are so separated, as to have no elasticity, unless they be acted upon by causes that can have no place in the living body, as freezing, putrefaction, or a total removal of the pressure of the atmosphere.

Besides the general and chief uses of respiration already mentioned ; to wit, effecting the trajection of the blood through the lungs, in order to comminute, condense, and round it's particles, and thereby adapt them to flow through the canals of various sizes in the body ; creating redness in it's globules ; generating heat, by the great friction in flowing through the capillaries there (though at the same time the air by touching the lungs moderates that heat by abating somewhat of it.) I say, besides these general uses of respiration, as nature always brings about the most numerous and most important purposes by the fewest and most simple means possible, that function hath several by uses, which are of the greatest consequence to the animal ; to wit,

It's being constantly exercised, and the diaphragm and abdominal muscles being always alternately in action, the abdominal *viscera* are with a continuance alternately pressed upon, and freed from that compression ; by which means, as we shall see afterwards, concoction in the stomach and intestines is promoted ; and the circulation through the system of the vena portarum, which otherwise would be too sluggish, is urged on.

The fæces and urine are expelled by it's efforts.

Smelling is performed, by inspiring or snuffing up air.

The foetus is excluded by it's assistance, and suction, so necessary for the preservation of the new born animal, is performed ;

LECT.  
VI.

And without it there could be no such thing as voice and speech brought about.

From what hath been said, we shall solve a question or two concerning this important function ; and first,

Why do animals soon die in the Boylean vacuum ?

Because there is not air to fill and expand the lungs, in order to unfold and streighten the small capillary vessels, that run along the membranous parts of the lungs. When they are collapsed, these small vessels, by being complicated, and as it were rolled together, would create too much resistance for the right ventricle to surmount, if it were not seconded by the expansion of the lungs in inspiration.

Why is the human species, and all land animals that have lungs like man, mortally suffocated so quickly, and almost in an instant under water ?

The late celebrated BOERHAAVE, in his prælections, used to mention this phenomenon as extremely difficult to be accounted for, and recommended earnestly to his students to attempt it's solution. This I have endeavoured to give in a small volume of English tracts, published in the year 1748, out of which give me leave to quote what concerns the problem.

In the first place, it is certain that drowning is not caused by the admission of water into the wind-pipe and lungs, there being many instances of persons taken up dead immediately after falling into water, in whose thorax, upon examination, there was not one drop found \*. Consequently, in drowning there must be an effectual shutting of the glottis ; other-

\* See Joan. Conrad. Beckerus de morte submersorum sine pota aqua, Jenæ 1720.

LECT. VI. wife water by it's pressure and fluidity could not but make it's way into the larynx, and fill at least it's larger branches, as their sides cannot be totally pressed together, upon the account of their cartilaginous rings. This constriction of the glottis is performed by proper muscles ; and is no doubt an automatical involuntary motion tending to self-preservation, of the same nature with the shutting of the eye-lids, or winking when any sudden hurt threatens the eyes. And indeed, without a quick and effectual closing of the passage into the lungs upon the approach of any thing whether liquid or solid, which, if it fell into them, would prove hurtful, we could neither eat nor drink safely, because in swallowing, the whole of the aliments must pass over the larynx before they reach the gullet. The glottis then being totally shut, neither water nor air can be admitted into the lungs, nor expelled out of them. But here begins the difficulty, where it would seem to end ? " Whence is it ? urges the no less modest and candid than knowing and learned professor, " that vital respiration cannot be continued " under water ; on the contrary, a mortal suffocation " quickly ensues ; though the thorax and lungs being capable of alternate dilatation and constriction from causes inherent in themselves, may seem " to be able to produce the same effects as common " air." That is in words more at large " since the " thorax by it's shape and structure is capable of " being alternately enlarged and straitened, and is " provided with muscles for these purposes ; and " since the lungs, independently of air, may be " alternately distended and squeezed into smaller " compass ; the former by blood thrown from the " heart into it's vascular system while the thorax is " dilated ; the latter by the pressure of the thorax " in collapsing, together with their own contractility, whether muscular or elastic ; by which alternate motions the circulation of the blood from

" the



“ the heart through the lungs (in which life pre-  
 “ cifully consists) might, as it would appear rea-  
 “ sonable to think, be still kept up, pretty nearly  
 “ in the same manner as happens in common re-  
 “ spiration in air, the principal effects of which  
 “ are reciprocal distention and collapsing of the  
 “ lungs; since such is the structure and mechanism  
 “ of these organs, whence it is that at least some  
 “ sort of respiration cannot go on under water,  
 “ sufficient to preserve the life of the animal for  
 “ some remarkable time, suppose a quarter of an  
 “ hour, but it is in an instant mortally suffo-  
 “ cated.”

To solve this difficulty, which I have endeavoured fairly to state, let us keep still in view the total shutting of the glottis, caused immediately upon the submersion of the animal; and continuing not only till mortal suffocation ensues, but even after; otherwise, as I have already observed, water must make it's way into the lungs of drowned persons, and fill at least the large branches of the wind-pipe; the contrary of which happens. This being laid down, it will plainly follow, that in whatever state the lungs are surpris'd by submersion, they must continue in that self-same state, and therefore will be capable of no alternate motion or change. If they are distended, and inspiration be compleated when the glottis is first constricted, then expiration cannot succeed in it's turn, because the air is pent up within the lungs, and by it's spring will resist the action of the muscles that serve to straiten the breast, and so the animal must perish in the same manner as it would be stifled in air, were it's mouth and nostrils perfectly stopt. Again, if the lungs are collapsed in the first moment of being sunk under water, they must remain so; inspiration cannot take place, because the pressure of the ambient water will oppose the action of the muscles that serve to widen and enlarge the thorax, there

LECT. being neither air nor water admitted into the lungs  
 VI. to counterbalance that pressure. To illustrate the  
 matter by a familiar similitude, as a pair of bellows  
 with both it's orifices stop't cannot play, but if at  
 first shut cannot be opened ; if open, cannot be  
 shut, (without an enormous force, such as in the  
 one case is superior to the whole pressure of the at-  
 mosphere without ; and in the other is sufficient re-  
 markably to condense the air within) in like manner  
 the lungs of a land animal cannot be alternately  
 dilated and collapsed under water, upon the account  
 of the passage of the wind-pipe's being effectually  
 closed. The air pent up within them will hinder  
 their being contracted, and the pressure of the wa-  
 ter without will prevent the dilatation of the chest  
 necessary to allow them space to be expanded by  
 blood thrown into their vessels from the heart ; for no  
 otherwise can they be expanded, while both air and  
 water are denied entrance.

It is in vain to urge, that blood thrown from the  
 right ventricle of the heart into the lungs may dis-  
 tend them, and so counterbalance the pressure of  
 water, and therefore leave the muscles that widen  
 the thorax at freedom to act. An animal dies  
 quickly in the Boylean vacuum, where there is no  
 resisting or pressing fluid, within or without, to  
 oppose either the contraction or dilatation of the  
 thorax ; and yet these motions cease : much less  
 can they go on, where there is a dead pressure of a  
 ponderous fluid to hinder the dilatation of lungs,  
 over and above the fatal exclusion of air.

Why do animals perish in stagnating air, in more  
 or less time ?

Because the air, by being drawn into, and ex-  
 pelled out of the lungs, becomes tainted with wa-  
 tery exhalations from their inner surface ; which be-  
 ing themselves not elastic, and at the same time  
 tending to an alkaline putrescent nature, taint the  
 air, as it were drowning it's elasticity, and render-  
 ing

ing it unfit for respiration. And therefore animals LECT. IV.  
 can live longer in the same space of compressed  
 stagnating air, than in air no denser than that of the  
 ambient atmosphere, as it is more slowly infected.

Divers, who are let down into the bottom of water to fish up what hath been sunk, are well acquainted with these matters. They are inclosed in a copper vessel closely shut, of a certain solid content, and so sunk; and they know by experience how long they can commodiously breath without the renewal of air.

Before we dismiss this function, let us observe that we may distinguish two kinds of respiration; to wit, the easy and equal kind of it, which goes on without our attention, and while we are asleep; this may be called vital, or involuntary respiration; and the other the voluntary kind, which we can influence by our will; and either excite, or stop, and make quicker or slower, fuller or smaller, as we list.

The former seems to be influenced chiefly by the diaphragm, and intercostal muscles in inspiration; and by a gentle proportionable action of the abdominal muscles in expiration, co-operating with the restitutive power of the cartilages of the ribs, and the muscular fibres that fasten together the cartilaginous rings of the trachea and it's divisions, called bronchia.

In this respect there is some difference observable in the sexes. Men use the diaphragm more, and the intercostal muscles less than women, in the common natural easy respiration. And there is a very good reason to be assigned for this difference; to wit, that the latter may the easier bear the great distention of the abdomen in pregnancy; in which the diaphragm, being pushed so far up into the thorax, can scarce act at all; and therefore that defect must be supplied by the elevation of the thorax. It was therefore necessary that this eleva-



**L E C T.** tion should be more exercised to render it easy, and  
**VI.** familiar, in women than in men, that it might  
 stand them in the more stead, when it should be so  
 much wanted.

In great, full, and laborious respiration, there are several other muscles besides those already mentioned that are called into assistance; for which I refer you to anatomists.

Lastly, let us remark that there is a certain proportion of the frequency of acts of respiration, to the pulse, there being in a common natural way about three or four pulses for one respiration. Hence respiration is quickened, as the pulse is quickened, either by exercise or in fevers. And therefore respiration ought to be diligently observed in acute distempers, as HIPPOCRATES did; who seems, as we have already observed, to have chiefly compensated his neglect of the pulse by a nice attention to respiration.

For a full account of respiration, besides BOERHAAVE and HALLER's Physiology, see a very accurate paragraph of MONRO's in his Osteology, concerning the bones of the thorax; and likewise a Treatise de Respiratione amongst the *Opuscula Anatomica* of HALLER; in which there are many experiments on live animals clearing up the subject.

## L E C T U R E VII.

*Of voice, and speech; and some diseases of the thorax and lungs.*

**L E C T.** **I**N our last lecture we have explained respiration,  
**VII.** We have seen, that in an animal that is furnished  
 with lungs, and hath used them even a very moderate time, the blood cannot be propelled by the heart through the lungs, without the assistance of respiration. That by this it's passage through the lungs the blood hath it's particles divided and comminuted; made denser and more compact; rounded,  
 and

and rendered red; and in general better fitted to pass through the various sizes of canals in the body, and furnish matter for the various secretions, than it would be without. That the heat of the animal body is in a great measure generated by the friction the globules of blood create in their passage through the small pulmonary vessels; as the velocity of it's motion through the lungs is very great: and, lastly, that besides these principal uses of respiration, it likewise serves and is a *conditio sine qua non* of bringing about several other by purposes, which are indispensibly requisite in the animal œconomy. We shall now briefly explain some of these, that have the most immediate connection with respiration; and afterwards touch upon some of the principal distempers, that have their seats in the lungs and thorax.

We shall begin with the voice and speech.

The human voice is either inarticulate, or articulate; the latter is called speech.

Inarticulate voice is a sound produced by throwing out air with a certain force or velocity through the glottis, or aperture of the larynx, so as to make the cartilages, of which the larynx is composed, to tremble and vibrate, and communicate the like tremulous motion to the contiguous air; but without being modified by the tongue, lips, teeth or throat.

That the cartilages of the larynx tremble upon the voice's being excited, may be perceived by the touch. Let any one put his hand to the larynx, when the voice sounds, he will feel a tremulous motion there.

Articulate voice or speech is that same sound produced by throwing air out of the glottis, but formed and modified by the lips, tongue, teeth and throat, in such a manner, as to produce an infinite variety of distinct sounds, and thereby enable us to communicate our thoughts to one another; and to represent these sounds by letters and words.

Every

L E C T.  
VII.

**LECT.** Every sound we utter is of a determined gravity  
**VII.** or acuteness, and of a determined loudness or low-  
 ness. The voice is rendered acuter, by making the  
 glottis narrower; and rendered graver, by widening  
 it. The raising of the larynx favours the coarctation  
 of the glottis, and the depression of it favours it's  
 enlargement, for all which actions there are proper  
 muscles.

The voice is made louder by throwing out more  
 air in a given time, or, which is the same thing,  
 throwing air with more force through the glottis,  
 while it's aperture remains the same.

The formation of articulate sounds, such as can  
 be represented by letters and words, is effected by  
 modifying the plain fundamental sound by the lips,  
 tongue, teeth and throat; and every distinct ele-  
 mentary articulate sound requires a distinct action  
 of the organs that are employed to frame it.

The narrowness of our course permits us not to  
 enlarge upon this subject. Whoever would under-  
 stand these matters to the bottom, let him consult  
 JOANNES CONRADUS AMMAN DE LOQUELA. This  
 extraordinary person taught people born deaf and  
 dumb to speak, and understand what was said to  
 them, not indeed by their ears, but by their eyes,  
 that is, by attending to the motion of the lips and  
 mouth of the speaker. They could neither hear  
 themselves nor their answerers speak, and yet were  
 enabled to hold conversation. He was likewise a  
 great artist at rectifying faults and imperfections in  
 speaking.

Common speech differs from musical sound or  
 singing in this respect, that (besides it's being arti-  
 culated) in common speech the voice passes from  
 grave to acute, or from acute to grave, not by  
 whole musical intervals, of which there are twelve  
 in an octave, but through all imaginable infinite-  
 simal degrees. But where every change of acute-  
 ness or gravity is made *per saltum*, by one or more  
 whole

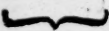


whole musical intervals, the sound becomes some kind of music or other, good or bad, harsh or agreeable. LECT. VII.

But of these things enough, as they are rather entertaining to the curious philosopher, than useful to the practitioner. We now go on to explain some other actions, that have a more immediate dependance on respiration.

**COUGHING** is produced by repeated quick inspirations, each of which is succeeded by as quick, forcible, hard expirations, caused by violent strokes of the abdominal muscles determined upon the lungs. It is created by whatever molests or irritates the pulmonic system, from the head of the larynx to the bottom of the lungs. It's effect, as a natural action, is to sweep, as it were, and clear the inside of the bronchia, by the violent impulse of air through them, and shake off the irritating cause. Coughing, when it is moderate, and keeps within due bounds, is of great service, by keeping the bronchia tight and clear, and pumping up phlegm or mucus, that will otherwise sur and dam up the air vessels. We shall speak more of it by and by, when we come to consider some distempers of the lungs.

**LAUGHTER** is that complicated action, occasioned either by the mind's being affected with some joke, or by the titillation of cutaneous nerves; in which, after one large inspiration, frequent little imperfect expirations swiftly succeed one another; the glottis being indeed open all the while, but kept narrow, that the air in the lungs may not get out too soon. Laughter, when moderate, may be serviceable, by recreating the spirits, and by affording a kind of exercise in shaking the sides. But when immoderate may have tragical effects, of which many instances are recorded; because the lungs not being completely evacuated while the fit of laughter lasts, the blood is stopt in them, and the circulation obstructed.

LECT. VII.  And it is not very uncommon to see people in excessive fits of laughter become black in the face, by the blood's being accumulated in the venous system between the evanescent branches of the aorta, and the right auricle of the heart.

WEeping or CRYING hath this in common with laughing, that it is attended with quick, short, imperfect exspirations and inspirations; but it is terminated by a deep expiration, which is immediately succeeded by a large inspiration. It is attended with tears, by the lachrymal gland's being in a particular manner squeezed by the *orbicularis palpebrarum* muscle.

STERNUTATION or SNEEZING is produced by first drawing in a large quantity of air into the lungs, then succeeds a violent convulsive action of all those muscles together, that can in any degree contribute towards expiration; by which means the air drawn in immediately before in large quantity is driven with a forcible explosion through the passage of the nose. It's cause is whatever molests the olfactory nerves spread upon the *membrana Schneideriana*; it's use is to shake, and sweep off the irritating cause, as wind blows off dust.

We now, according to the plan of our lectures, proceed to give an account of some of the principal distempers, that affect the lungs and aspera arteria; and thereby exemplify the usefulness of the knowledge of the animal œconomy in the rational practice of physic.

We have already mentioned and explained coughing as a natural action, we shall now consider it as a morbid symptom.

COUGHING, as we have said, is an effort of nature to shake off something that is troublesome to the pulmonary system. Though this effort tends in it's own nature to a salutary purpose, yet it may be over violent, or continue over long, and so hurt rather than benefit the patient; and likewise the cause of cough-

coughing may often be carried off in a shorter or LECT. VII.  
 more effectual manner by art, than by the natural  
 continuance of that symptom; and therefore practi-  
 tioners are often obliged to direct remedies against  
 coughing; and not seldom, as in violent colds, and  
 consumptions from the lungs, it is the most urgent  
 symptom, and requires the chief artillery of reme-  
 dies to be directed against it.

The most frequent cause of coughing is what is  
 commonly called catching of cold, and in LATIN  
 gravedo and catarrhus. The seat of this disease  
 is the membrana Schneideriana, so called from  
 SCHNEIDER, a learned German physician, who first  
 considered it at large, and it's diseases, in a work  
 entitled De Catarrho, in ~~four or five~~ volumes in 4<sup>to</sup>.  
 This membrane lines the cavity of the nose, the  
 palate and throat; passes into the cavity of the  
 larynx and aspera arteria, and lines the inside of  
 the whole system of air vessels in the lungs; and in  
 like manner the inside of the œsophagus, stomach  
 and intestinal tube. It's surface hath, besides vi-  
 sible mucous, excretory ducts, scattered up and  
 down, small evanescent serous arteries opening  
 upon it, which convey a warm watry moisture,  
 which in health is in the form of a vapour, and  
 keeps it moist and slippery, and hinders it's conti-  
 guous portions from growing together; and as it is  
 accumulated, there are in the same surface absor-  
 bent venous vessels to take it up. But when by the  
 cold air the absorbent vessels are constricted, and  
 the vaporous fluid condensed, the exhaling arterial  
 canals continuing to pour out their liquids, instead  
 of a warm vapour, that creates no irritation upon  
 the parts, a sensible salt ichor or lymph is discharged  
 from the various affected parts of the membrane,  
 and irritates wherever it trickles along: if it falls  
 upon the nostrils, it creates sneezing; and if it fall  
 upon any portion of the pulmonic system, from  
 the head of the larynx to the bottom of the lungs,

it

X June or July



LECT. it creates coughing; and a cough so created, and obstinately continuing, too often, in the British climate, VII. lays the foundation of a phthisis pulmonalis.

The cure of this cough, while it is recent, and the lungs are yet entire and unimpaired, besides keeping warm, and drinking thin watery liquors, and living low, and encouraging a diaphoresis, requires balsamic, smooth, demulcent loches and linctuses, and a prudent use of opiates : by the application of which, after the distemper hath in some measure had it's course, the obstructions in the membrane being opened, the catarrh or defluxion is drained up; and the irritating cause taken away.

Another very common cause of coughing, is an accumulation of tough phlegm in the bronchia. As we have observed, there is naturally a warm moist vapour poured by small serous arteries into the cavities of the bronchia; as injections shew : now if this is poured out in too great a quantity, by remaining there, it becomes thickened, the thinner and aqueous part either flying off into the air, or being resorbed, the remainder becomes viscid; and irritates the lungs, and excites a cough, which is the only way to get rid of it. This cough is cured or relieved by such medicines as attenuate the impacted phlegm, lubricate the passages, temper acrimony, and leave a balsamic astringent effect, preventing the reaccumulation of a like too great quantity of phlegm for the future; and such medicines as possess one or more of these powers in a remarkable degree are called pectorals.

Some pectorals have chiefly a faculty of tempering acrimony, and lubricating the passages, as sperma ceti; all expressed oils, and oily substances. Others chiefly attenuate, dissolve, and deterge phlegm; as liquorice and other pectoral plants, sugar, honey, vinegar, gum ammoniac, &c. others are besides astringent and balsamic; as all the terebinthinate class, and their preparations.

Opiates

Opiates become pectorals or bechics chiefly, and LECT VII.  
almost solely, by taking off the sense of irritation, without carrying off the irritating cause; but however they are of great use, by keeping down the violence of cough, and procuring a truce, until the cause be removed by other effectual methods.

HOARSENESS most commonly proceeds from a relaxation, swelling, or obstruction of those parts of the membrana Schneideriana that are spread on the larynx, and upper part of the aspera arteria; which are the parts most immediately concerned in producing the voice; from which it happens, that their cartilages by their vibrations cannot excite so clear a sound as they should do. In like manner, if you cover a bell with a cloth, it's sound will be spoiled.

It's remedy is to give often deterging balsamics that have an astringent quality, with a mixture of oilyness; yolks of eggs, sperma ceti, honey, sugar; syrups of pectoral vegetables, as maiden-hair, tussilago, erysimum, hore-hound; the balsamum traumaticum; polychrestum, and the like, are the chief remedies in this disorder.

ASTHMA is a difficulty of breathing, with wheezing, returning by fits, and often lasting long, and threatening suffocation.

Authors have distinguished it into the nervous and humoral, and I believe justly, so far, as to denote that every asthma leans to one of these two kinds more than the other. But I am of opinion, that they are seldom or never to be met with pure and unmixed.

The humoral kind, is that which is occasioned by an accumulation of phlegm or mucus in the small and deep bronchia; which, when it is in a great quantity, and occupies a large enough portion of them, hinders the air from expanding the lungs sufficiently, and expediting the passage of the blood through them.

The

LECT. The nervous, sometimes termed convulsive,  
 VII. asthma, is created by a convulsive constriction of  
 the muscular fibres that connect the cartilaginous  
 rings of the bronchia, which makes the lungs to  
 resist their being expanded by the air. A spasmo-  
 dic disposition in the muscles of the abdomen,  
 overpowering the diaphragm, may be an accessory,  
 or perhaps in some cases a principal cause of this  
 sort of asthma.

But as I have said, I believe that if the asthma is  
 of any remarkable violence, or continuance, it is  
 seldom or never without a mixture of both natures.  
 An asthma from a nervous cause, of any conse-  
 quence, can scarce fail of accumulating more  
 phlegm than there should be, by penning it up,  
 and hindering the salutary display of the lungs in  
 order to pump it off. And where there is a great  
 quantity of phlegm, so as chiefly to produce real  
 asthmatic fits, there appears always, as far as I  
 have observed, signs of a spasmodic disposition,  
 and constriction of the lungs.

In the humoral kind, besides a prudent mea-  
 sure of proper evacuation, the most effectual in-  
 ciding and attenuating pectorals are indicated.  
 Pectoral vegetables, the spirit of Mindererus, gum  
 ammoniacum, squills, and, in violent cases, anti-  
 monials and mercurials are most to be depended  
 upon.

In this nervous asthma cephalic medicines are re-  
 quired; but not without the mixture of attenuants.  
 The fetid gums act here in a double capacity.  
 Blisters operate like a charm; and are far from  
 being amiss in the other kind.

HÆMOPTOE, or spitting of blood, if it comes  
 not from the mouth or throat, but is brought up  
 from the breast, with a kind of short cough, in a  
 remarkable quantity, and frothy, proceeds from a  
 breach of some of the branches of the pulmonary  
 artery.

This



This symptom, when it arises from an internal LECT. VII.  
 cause; that is, when it is not brought on by external  
 violence, most commonly attacks young men and  
 girls, soon after they arrive at their full height of  
~~nature~~; and chiefly such as are thin, have long  
 necks, and have waxed tall very fast. + Stature

A breach of vessels in the lungs is of more dangerous consequence, than in many other parts of the body, because of their incessant motion, the velocity of ~~their passage~~ through them, and the spongiousness of their texture. Upon these accounts it is apt to degenerate into an ulcer. Great care therefore is to be taken to treat it properly when it first appears, that the breach may be cemented as soon as possible. Bleeding, gentle cooling physic, cooling temperate diet, with opiates, and such balsamic pectorals as can best keep the cough under, are here requisite. If the hæmorrhage is large, astringents, and even styptics are necessary, of which alum is none of the least effectual. The passage of blood.

I have seen near a quart of blood brought up from the lungs in a few minutes. The patient had many such returns, and yet he perfectly recovered.

A vomica pulmonum is a little knot or tubercle, bred in the cellular texture of the lungs; which contains sometimes pus, sometimes a viscid liquor different from pus, and sometimes a clear pellucid lymph. This last sort is called hydatid. The vomica grows larger and larger by degrees, and creates more and more of irritation, by pressing the contiguous air vessels against one another; and so produces the same sensation, as if something were within them obstructing their cavities: and therefore excites an almost perpetual cough, and lays the foundation of a phthisis pulmonalis.

If it bursts, it becomes an open ulcer. And if the matter is kindly, the habit of body good, the tumor circumscribed, and it's coats but thin, it sometimes cleanses, and heals speedily and well:

H

but

LECT. but too often the ulcer continues to increase and  
 VII. spread; the patient coughs almost incessantly,  
 and throws up much fetid stuff, his lungs waste,  
 he is consumed with an hectic fever, and dies.

It is for the most part an incurable distemper, if it be of pretty long standing. Such balsamic pectoral medicines as are safely detergent, and resist putrefaction most, are here in a peculiar manner requisite. These with a prudent use of opiates, and proper diet, are the chief means to effect a cure, where it can be effected.

An ulcer of the lungs, as hath been hinted, may proceed from a spitting of blood, without a previous tubercle, and goes on pretty much in the same course we have been now describing; requiring the same method of cure and regimen.

### LECTURE VIII.

*Of the nature and properties of the blood. Idea of fever.*

LECT. **I**N the foregoing lectures we have discoursed at  
 VIII. large on the motion, or circulation of the blood,  
 and have treated on respiration, without which, in a born animal, it's passage through the lungs cannot be effected: it is now high time we should examine into, and explain, the nature and properties of the blood itself.

And it is so much the more convenient so to do in this place, as the functions of the brain and nerves must be treated of by and by; since they influence and keep up the action of the heart and motion of the blood.

But secretion is the leading operation of these organs; and therefore an account of secretion is to be premised to that of the brain and nerves.

And that animal action being only a separation of various juices or liquids from the common mass

of blood, differing in some respects from the mass L E C T. VIII.  
itself; order and method require that the nature and properties of this fluid should be first laid open, out of which the various secretions are made, and the various liquors answering the numerous purposes of the animal œconomy drawn.

We shall first consider the blood, as it appears to our unassisted senses, little, if at all, changed by art; next we shall deliver what is discovered concerning it by microscopes; and lastly enumerate the different substances it yields when chemically analysed.

The blood of a person in health, let out casually by a wound, or designedly for the prevention of plethora, appears first an homogeneous fluid, uniformly red, and remarkably thicker than water.

While it remains warm, it throws off a vaporous *halitus* or steam, of a smell betwixt that of sweat and urine. This vapour, if collected in vessels for that purpose, when condensed by cooling, is found to be a limpid water, lightly impregnated with native animal oil and salt, inclining to alkaline nature.

As the mass cools, it gradually thickens into a gelatinous consistence. It's surface exposed to the air is of a lighter and more florid red than the substance within, and at the bottom; which is darker and inclining to black.

This *coagulum*, consisting of the whole of the blood except the vaporous steam we have mentioned, is found to be specifically heavier than water, by about a twentieth part.

The longer this *coagulum* stands in a place no warmer than the ambient air, the more it is changed. It parts with, or rather is dissolved into, more and more of a thin yellowish fluid called it's *serum*, (like the whey of milk separating from the curd, from which resemblance probably it hath it's name.)



LECT. name.) This *serum* is heavier than water by more  
VIII. than a fortieth part.

The red part, called *cruor*, *crassamentum*, and sometimes, but improperly, it's fibrous part, as there are no fibres naturally in the blood; and sometimes *insula*, is considerably heavier than the *serum*; and therefore always settles at the bottom of the dish. See upon this subject, JURIN's accurate experiments in the Philosophical Transactions, N<sup>o</sup> 361.

This red part or *crassamentum*, if dried by art or chance, before it is melted down into *serum*, or dissipated by putrefaction, becomes hard and brittle, and entirely inflammable, and therefore oil is the chief part in it's composition, next to water.

The whole blood, both *serum* and *crassamentum*, if it stands long enough in a warm place, putrefies and flies off in fetid effluvia, leaving very little *feces*.

The *serum*, and likewise the *crassamentum*, by a degree of heat somewhat less than that of boiling water, is coagulated like the white of an egg. They are likewise coagulated by alcohol, and strong mineral acids.

They both leave a slight saltish taste upon the palate, shewing some kind of salt to be an ingredient in the composition of the blood.

These are the principal and most obvious phenomena of the blood, when examined by the unassisted senses; and with little or no artificial apparatus.

By the microscope more of it's nature and constituent parts is discovered. From a small wound made by a sharp instrument, suppose a prick in the finger, let a drop of blood be received into a small glass tube, and examined with a good microscope, which needs not be the highest magnifying sort; it appears not homogeneous, but consisting of red globules swimming

+ almost

in a pellucid liquor. And, according to LEWENHOEK, these globules, when more accurately viewed, are found to consist of six lesser ones; which, though when joined they render the large globule they compose, red, yet are not red separately, but of the colour of the *serum*, to wit, yellowish, with a considerable degree of transparency.

And farther, the same author pretends to have spied a third series of globules, six of which go towards the formation of a serous globule; as the like number of the latter make up the largest kind, to wit, the red globule.

BOERHAAVE, who was an intimate friend of LEWENHOEK's, and even directed him in some of his researches, and probably sometimes made use of his glasses himself, that he might see things with his own eyes, admits all these phænomena we have mentioned as strictly true, and unexaggerated, and even builds a system upon them; concluding, that though our sight, however assisted, can go no farther than to discover a third series of globules, yet nature does not stop there, but probably has still more series orderly decreasing, and classes of vessels in the body, adapted to receive the different kinds of globules respectively, and to exclude all others of a larger size.

The generality of physiologists likewise have received LEWENHOEK's doctrine of subordinate globules. Even the clear sighted, as well as the indefatigable, HALLER admits it both in his Commentaries on BOERHAAVE's Prelections, and in his *Primæ Lineæ*, though with more reserve in the latter work, than in the former.

Whether this doctrine is right or not, I shall not pretend to determine upon my own small experience in microscopical matters. I shall only lay before you the doubts that the observations of

LECT. others have raised against it, and leave you to judge  
VIII. for yourselves:

SENAC, in his elaborate and voluminous treatise on the heart, informs his readers that, after taking all the necessary pains, he could never observe any other kind of globules in the blood, but the largest and red sort; and that they appeared to him, not perfectly spherical, but of a lenticular figure, that is, flatted on the two opposite sides.

If his authority should be the less regarded, because he is too apt to find fault with other writers, let me mention another.

In the inaugural thesis published and defended at Gottingen, in the year 1752, entitled, *Experimenta quædam circa circulationem sanguinis instituta*, by G. ERNEST REMUS, I find the learned and ingenious author, though in the making of his experiments he was honoured with the presence and assistance of professor HALLER, and professor HOLMAN, the latter much versed in microscopical observations; though he used a variety of microscopes, even the solar one; yet frankly owns he could not so much as make out distinctly by ocular demonstration the figure of the largest and red globules; much less could he discover a subordinate series, which by their ~~adhesion~~ <sup>adhesion</sup> and cohesion made up the largest sort. He concludes, indeed, the larger globules to be spherical, or nearly so; but that he does from reasoning, and not *autopsia*; because, says he, the middle parts of the globules being thickest, appeared of the most intense red colour; the exterior parts looked paler, and lighter, as being thinner. He likewise acutely infers, that these globules cannot be remarkably lenticular, as SENAC conceives them; because if they were so, the thinner edges would sometimes present themselves to view, and form a different appearance; which in his often repeated trials never was the case. And this is all he could make out by the microscope.

Now

+adhesion



Now if it be so difficult to see distinctly the figure of the largest globules, to determine by *autopsia* whether they are spherical or lenticular, how much more so must it be to find out that the largest globule is not one solid sphere, smooth and even, but like a rasp or mulberry composed of many sticking together? And what shall we say, of LEWENHOEK's pretended discovery of a third series, as much smaller than the second, as the second is smaller than the first?

Here is not solely an unexperienced student at the head of the enquiry, but two celebrated professors assisting him with zeal; to wit, HALLER, no stranger to minute objects, with very good eyes, as may appear from his botanical works, and HOLMAN trained up in exercises of this nature. And the candidate is by the former highly complimented, for his merit and abilities upon the publication of this very thesis.

These considerations I own make me quite a sceptic, with respect to LEWENHOEK's discoveries concerning the subordination of globules; and all, I think, we are authorised to conclude in this matter is, that the blood consists of red globules swimming in a *serum*, of a figure either spherical, or nearly so.

These red globules, though they are the largest of any of the particles of the blood, are yet extremely minute and small. JURIN defines their diameter to be about the 2000th part of an inch, and HALLER takes it a whole third less.

In viewing the circulation of blood through a microscope in the transparent parts of small animals, as in the tail of a tadpole, or the foot of a young frog, observers have seen in the smallest vessels that admit red blood, sometimes only a single globule filling the whole vessel.

Authors have pretended to spy saline spicula in the serous part of the blood; but I should as little

+ Haller in  
his latest  
Work viz  
Element.  
Physiology.  
makes them  
still much  
smaller.

LECT.  
VIII.

LECT. trust to that observation, as to what hath been said  
 VIII. of a second and third series of globules. The  
 truth of the matter is, that when very great magnifiers are used, the unequal refraction of the rays and shades confound all; so that it is very far from being easy to make a right judgment of the appearance of objects so viewed. It requires a suitable genius, good eyes, and great experience in such trials: nor has it ~~been~~ seldom, that great men have drawn opposite conclusions concerning the same objects. Imagination, conceit, and prejudice in favour of a particular opinion, have as much influence in these matters as elsewhere.

+  
 happens

Much pains hath been taken to analyse the blood chemically; first by the illustrious BOYLE, and after him by others innumerable.

In the first place, blood new let is found to be neither acid nor alcali; as BOERHAAVE hath proved by experiments in his Chemistry. It exhibits no phænomena, from which it may be concluded, that it belongs to either of these classes; but is indifferent to both; as likewise every sound animal humor is, urine itself not excepted.

A quantity of blood new let, neither dried by being too long exposed to the air, nor in the least tainted by putrefaction, being put into a glass retort of a proper size, and distilled, yields first, by a gentle heat, a copious water or phlegm, almost insipid, but somewhat impregnated with an empyreumatic oil; and the more so, the longer the distillation is continued. This water or phlegm is about five sixth parts of the whole.

What remains, being urged by a stronger degree of fire, yields that which is called the spirit of blood, being a fetid acrid liquor, of a reddish colour, like spirit of hartshorn unrectified. This liquor is the animal salt now rendered volatile by the fire, mixt with a small quantity of phlegm, and some of the still adhering animal oil, to which

which it's colour is owing. This spirit is about a <sup>L E C T. VIII.</sup> twelfth part of the whole.

The distillation being continued, and the heat increased, there rise together an inflammable oil and a volatile salt. The salt is about a fiftieth part of the whole; and the oil that rises with it pretty much in the same proportion. The longer the operation is continued, and the more the heat is increased, the oil becomes the thicker, heavier and darker coloured; being at the last black and hard, almost like pitch.

At the bottom of the retort there remains a *caput mortuum*, or charcoal, porous and inflammable; ~~composed of~~ an heavy black oil, which no heat can force over the helm, and separate from the other principles; but calcination in an open fire destroys and consumes it, leaving ashes behind.

*Not containing*

These ashes being dissolved in water yield a fixed salt, though in a very small quantity, little more than the thousandth part of the whole, and some insipid inodorous earth about the hundred and fiftieth part of the whole.

The fixed salt is found to be compounded of true sea salt, and alkaline lixivious salt. The latter is to the former in the proportion of one to three.

BOERHAAVE, in his analysis of the blood, finds no fixed salt in it's *caput mortuum*; which doubtless was owing to his having distilled but a small quantity at a time.

*+ alkaline*

The fixed salt, (to wit, both the sea salt and alkaline salt together, as they are obtained from the *caput mortuum*) when urged by the strongest possible degree of fire, yields a small quantity of acid. The sea salt and acid of the human blood might be thought owing entirely to the salt we take with our aliments; but since the blood of animals, that live entirely on herbage and water, likewise yields a small quantity of acid, perhaps it may in some measure, even



LECT. even in the human blood, be owing to the vegetable nature of our food left imperfectly subdued by the concoctive powers, as HALLER thinks; or, which to me appears not improbable, there may be true sea salt in the water that ~~gramineous~~ <sup>grainivorous</sup> beasts drink, or in the juices of the vegetables they eat, which yields that acid.

The earth of the *caput mortuum* of the blood, when freed from it's fixed salt, is found to contain some particles which the loadstone attracts; and therefore no doubt are of the nature of iron.

The *serum* of blood, distilled without the *crassamentum*, yields, in this operation, the same principles, but a greater proportion of water, and less of the oil.

This is the most exact and completest analysis of the blood, that chemistry hath hitherto furnished. But we must not think that these principles existed in the blood, in a natural state, the same as chemistry shews them. The fire renders it's salts alkaline and volatile, which before were neutral and more fixed; and it's oils acrid and empyreumatic, which before were mild and sweet. If after distillation all the substances the blood yields thereby, were again mixed together, they would make up a composition widely different from natural blood.

But we may fairly conclude, from this analysis, that blood consists of parts very different in their nature and properties, from each other; to wit, water, which is it's vehicle, and vastly the greatest part of it; oil, which is the next greatest; some kind of salt, which the fire renders almost all volatile; and earth, in the chemical sense of the word.

As all the parts of the body, both solid and fluid, (I mean such fluids as have undergone the effects of the circulation) are made out of blood, so they consist of the same principles differently combined and modified; for these principles are too permanent to be changed essentially by any force within the body.

body. Wherefore it is found by chemical experi-  
ments, that any part whatsoever of the animal  
structure yields the very same principles, that blood  
does. Horns, hoofs, bones, hair, silk, &c. all  
yield water, (and in a much larger proportion than  
one would expect from so dry substances) oil, vo-  
latile salt, and earth. The chief difference hither-  
to observed, betwixt the analysis of the blood and  
that of the solid parts, is, that the latter yield no  
fixed salt, as the former does.

For a full detail of the nature, properties and  
analysis of the blood, see, besides the writers of  
systems of physiology, the chief of which upon  
this subject are BOHNIUS, VERHEYN, BOERHAAVE,  
and HALLER; I say, besides these, see BOYLE,  
BOERHAAVE in his Chemistry, and the Hæma-  
tologia of SWENCKE.

*X*  
*Vicussent;*  
*Langreth;*

After having explained the nature and properties  
of the general fluid mass, out of which all the par-  
ticular liquids, or humors in the animal œcono-  
my are drawn and made, we should now proceed,  
as hath already been hinted, to unfold secretion.

But as it is one chief part of the plan of these lec-  
tures, to illustrate some of the most important parts  
of pathology, by the animal œconomy; we shall  
here say something briefly on the nature of fever.

Fever may be defined, a morbid circulation in-  
creased to such a degree, and of such duration, as  
remarkably to hurt the constitution by it's imme-  
diate effects, and disturb, pervert or impair the  
animal functions.

Fevers in general are divided into two principal  
classes, to wit, the continued and intermittent.

A continued fever, is that in which the pulse  
continues quicker than it is naturally from the be-  
ginning to it's termination, or crisis.

An intermittent fever is made up of different  
fits, or paroxysms, between each of which the  
pulse returns to it's natural slowness.

In

LECT. In every fever, whether continued or intermit-  
VIII. tent, that is produced by an internal cause (by

which is meant a cause pre-existing within the body before the fever is brought on, by what means soever it was first introduced into the body) there is, at the beginning for the most part, a coldness or chillness, greater or lesser, sometimes amounting to shivering and shaking; I have said for the most part, but I believe I might have said always; for though in practice we meet with instances, in which we cannot learn that such a chillness preceded, yet there might really have been some slight perception of that kind, which the patient himself either did not attend to, or might have forgotten: and from the perception of this, the æra of the fever begins.

In this state of coldness, chillness, shivering or shaking, the pulse is always quick and small: sometimes so quick that it's beats can hardly be numbered; and so small as scarce to be felt. And the body in general is colder and paler than in health, especially in the extremities.

Therefore in this state, there is, in some measure, a stagnation of the blood in the capillaries, from an unusual resistance there. And as the human machine is so made, that when it is out of order, it endeavours to set itself to rights the best way it's structure will permit, the heart labours to surmount this resistance; and what it wants in force, it strives to make up by the quick repetition of it's efforts.

After this state of chillness hath lasted some time, more or less according to the strength of the cause, and the constitution of the body affected, there succeeds an heat greater than in health, with a fuller and freer pulse than before, and continuing still quicker than it should be. And this increased heat, fulness and quickness of the pulse is, in a general way, proportionable  
to



to the degree and duration of the chillness in the first LECT. VIII.  
state. If the heart and powers that actuate it should not be able to get the better of the resistance that produces the chillness, the patient must soon die, it being impossible that life should continue long in that state. It is, in every respect, like to that of a dying person. Hence those that die of intermitting fevers, through a decay of constitution by age or otherwise, are mostly carried off in the cold fit.

But when the heart gets the better of the resistance that produced the chillness, there must succeed a greater heat than in health; because both it's force must be increased in order to surmount it, and as it finds the vessels contracted, and as it were collapsed by the stagnation, and the blood in some degree condensed by the coldness, the attrition of the globules of blood upon the sides of the capillaries, and consequently the heat, which is the effect of that attrition, must be greater, than if no coldness had preceded; there being upon that account both a greater *impetus* of the heart excited, and a greater resistance to that *impetus* produced.

After this first state is over, the heat and quickness of pulse, or which is the same thing, the fever goes on, continuing a shorter or longer time, and producing different symptoms, according to the different causes that brought it on, and according to the state of the body it seizes; or according to the management of the patient under it; terminating sooner or later, either in perfect recovery, death, or another disease.

So that fever is in reality an effort of nature to rid itself of something noxious. When there is any how such a quality or condition introduced into the habit of body, as would terminate in the destruction of the animal if the cause were not removed; in that case nature, or the vital principle raises fever, by which the peccant matter may be attenuated, comminuted, or otherwise changed; and so impelled  
and

**L E C T.** and driven about, that it may be assimilated to  
**VIII.** sound juices; or, if that cannot be, that it may be  
 prepared and fitted for expulsion, and at length expelled by some or other of the various outlets of the body, by sweat, which is the most frequent way; urine, stool, vomiting; hæmorrhage, and perhaps by insensible perspiration.

Fever therefore is in it's own nature good; and though a great many die of fevers, yet I believe that, if our bodies were not endowed with a power of exciting fever upon different occasions answering to the exigencies of the constitution, very few of the human species could be kept alive for months together.

But though fever in it's own nature hath this salutary tendency, it oft becomes the instrument of death in this mortal state checkered with good and evil. It may kill by over-doing it's work, and quickly destroying some vital part before the cause, which it endeavours to conquer and expel, is effectually subdued; or by being too languid it may prove insufficient to answer the end, and by it's continuance add the bad consequences of fever to those of the cause that brings it on, and between the two the patient may in the end be destroyed. Art therefore is oft necessary, and steps in successfully to assist nature in her well directed efforts. And, indeed, if in any disease, the direction of a prudent practitioner is always desirable in fever, if it were upon no other account than to regulate diet and the manner of living; and hinder the patient, or those about him, from entering upon improper and dangerous methods and measures.

BOERHAAVE, with his usual penetration, judgment, and precision, divides the general indications of cure into four heads: we shall here for conciseness sake reduce them to three; making but one of his second and third.

## PROPERTIES OF THE BLOOD, &c.

III

The first is, to take care properly to support the L E C T.  
VIII.  
vital strength.

It is life and vital strength, or what by another name is called nature, that gets the better of fever or any other internal distemper: I mean distempers in which chirurgical operation is not indispensably necessary. Nature, as we have said, may in some cases over-do her work, in others under-do it. If she is over impetuous, she must be weakened and restrained; if languid, she must be lashed and spurred on. We must not, like the bulk of the French, Spanish, and Portuguese physicians, bleed, glyster, and purge, till we take away all fever; this would be taking the instrument out of nature's hands, by which she is endeavouring to set the body perfectly to rights again; but we ought to leave such a degree of it, as we apprehend may be sufficient to enable her to do her work, and yet not endanger the destruction of any of the vital viscera. The pulse is the principal standard to judge of the strength by; (but not altogether without comparing it with the other faculties and functions of the body.) If it is too full, high, and quick, it is to be lowered. Blood letting; gently opening, cooling, glysters; dilution, by copious watry drinks; thin, cool nourishment, and very moderate warmth, are indispensably requisite here.

If the pulse flags, and the fever is too low, safely warming stimulating medicines, a richer, warmer diet, blisters, and more heat are indicated.

The second general indication, is to assist and co-operate with nature in subduing and expelling the cause that originally brought on fever; or, which is the same thing, that cause that prompted nature to excite fever, in order to conquer and get rid of it.

In the chillness, that precedes the febrile heat, we saw there is a resistance, which creates a kind of stagnation in the smallest vessels; and in fever there is, after the chillness is over, a heat greater than naturally,



LECT. turally, which denotes greater attrition than there  
VIII. should be in the smallest vessels : now in both these

cases there must be in the blood, or the thinner juices derived from it, an unusual cohesion in some of the minute particles, that create that resistance, and that attrition ; this cohesion BOERHAAVE with BELLINI, and other writers, calls *lensor*.

In the fever all along there is an increased celerity of pulse, both in the chillness, and the succeeding heat ; but the immediate cause of an increased celerity of pulse is something that urges and stimulates the auricles and ventricles of the heart into too frequent contractions. This cause, whatever it be, BOERHAAVE calls the *acre*, or *acrimony* ; we may likewise call it *stimulus*.

So that in every fever there is the *lensor*, and the *acre*, or *stimulus*, we have just now been explaining.

The second general indication therefore requires, that we should co-operate with, and assist nature in correcting, and expelling the *acre*, or the *stimulus*, that produces the over frequent contractions of the heart ; and in resolving and expelling the *lensor* that keeps up the resistance, and attrition, in the smallest vessels, and the consequences arising therefrom.

The *acre*, or *stimulus*, is to be corrected, and rendered harmless, either by the general method of dilution and mitigation ; or by the specific known antidote of the known *stimulus* ; or by general febrifuges known from experience ; as the bark.

It is to be expelled after dilution, by encouraging, or forcing such evacuations, as appear most suitable in the present juncture ; as sweat, urine, stool, vomiting or insensible perspiration.

The *lensor* is to be attenuated by dilution, brought about by such resolvents as are found by experience to be effectual for that purpose, as nitre, saline juleps, &c.

And it is to be expelled by the same means that the *stimulus* is.

I the rather chose to join these two indications together, because I apprehend, that often in fevers the lentor and the stimulus may be one and the same thing; that is, the preternatural cohesion of the juices that produces the resistance; and the attrition may be the sole cause of the frequent contraction of the heart; nature endeavouring by such efforts to comminute the lentor, and either change it into a due fluxility, or expel it.

The third and last indication is to relieve, mitigate, or totally remove troublesome and dangerous symptoms.

By taking off, or even mitigating troublesome symptoms, so much is gained in the patient's favour, and so far the agency of the principal disease is diminished, that the patient will bear it the better, and pass his time the more easily; provided always that no subsequent bad effects be influenced by measures taken for that purpose, and that while symptoms are chiefly attended to, the main thing, to wit, striking at the root of the principal distemper, is neither thwarted nor neglected.

And dangerous symptoms are to be levelled at with as great vigour and diligence, as the principal disease itself.

But to prosecute this subject farther is not my intention in these lectures; I only design by such excursions to illustrate the grounds of sound practice in some important instances; and shew the connexion between the rational art of healing, and a knowledge of the animal œconomy.

## LECTURE IX.

*Of secretion and glands. Of scirrhus and cancer.*

**H**AVING in our last discourse considered the nature and properties of the blood, that general animal fluid mass, out of which all the

LECT. other liquids are made, we come now to explain  
 IX. the way and manner in which fluids differing from  
 blood are made out of it, and separated from it;  
 and this is called animal secretion.

As on the one hand, nature always employs the most simple means to bring about her ends; so on the other she is never deficient, nor niggardly in contrivances to do every thing in the best manner. She equally avoids redundancy and defect.

In the human body, and that of other animals of the more perfect kind, a great variety of different juices is required to answer a like variety of purposes; all which are furnished out of the same general mass. Here then is variety joined to simplicity; the animal, by certain powers it is endowed with, first makes red blood; and then out of red blood, by other powers, it draws off, and forms all the other juices.

We shall, before we enter upon explaining the manner in which secretion is performed, with HALLER, take a short view of the several kinds or classes of animal liquids that are different from blood, and made out of it: a great part of which, especially such of them as are of the most general importance to the animal œconomy, shall be more fully and particularly considered afterwards.

He divides them into four classes.

The first comprehends those liquids which have such a degree of viscosity, as to be coagulated by fire and by alcohol, like the white of an egg, and yet in the living body exhale in the form of vapour, but after death, when all is cold, are condensed into a kind of jelly. Of this sort is that vaporous *balitus* we have already had occasion to mention, that exhales into cavities, and hinders the parts from growing together, as into the cavity of the abdomen, where, when accumulated in too great quantity, it creates ascites; into the cavity of the thorax, where it forms frequently those least hurtful adhesions



sions of the membrane of the lungs to the pleura; L E C T. IX.  
 into the ventricles of the brain, where it often creates apoplexy; into the cavity of the testis, formed by the tunica vaginalis, and there by it's accumulation produces the *hydrops testis*; into the cavity of the amnion, there furnishing the liquor amnii; into the articulations, to lubricate the extremities of the epiphyses, and make them move easily over one another; into the cavity of the uterus, to hinder it's walls from growing together, and preserve it's distensibility. Such likewise is that clear, saltish, liquor which is supplied to the stomach by the serous evanescent arteries of it's villous coat, and is often called *liquor Gastricus*, and that of the intestines of the same nature. And such, lastly, is that liquor contained in the lymphatic veins discovered by BARTHOLIN and RUDBECK.

The second class contains those, which being thinner, and more watry than the former, are neither coagulable by fire nor alcohol. Some liquids, of this class, are naturally exhaled from the body; as the matter of Sanctorian perspiration; and a part of the tears; for some of them being poured out upon the cornea and albuginea, must be evaporated into the air, while the remainder is taken up by the puncta lachrymalia, and sent into the lachrymal sack. Other liquids of this second class are not evaporated, but carried off into a destined place by proper excretory ducts. Such is that part of the tears, we have just now mentioned; the saliva, the pancreatic juice, and urine. To this class of thin liquids, not coagulable by heat or alcohol, but entirely evaporable, belongs the nervous fluid, separated by the brain, if such a fluid there be.

The third class of liquids consists of such, as are not coagulable by fire and alcohol, at the same time are not gelatinous, but watry, with some degree of viscid tenacity; and when the watry part

LECT. is dissipated, leave tough, hard crusts behind. Of  
 IX. this kind is what is called *mucus*, or phlegm, which  
 is found throughout all the respiratory passages from the mouth and nostrils to the extreme and remotest vesicles of the lungs; over all the alimentary passages from the *fauces* to the *anus*; throughout the urinary passages from the ureters (inclusive) to the extremity of the *urethra*; and in the cavities of the genital organs of both sexes. Of this kind likewise is the *semen masculinum*, and the liquor of the *prostatæ*.

The fourth and last class comprehends the inflammable humors, which though, when newly drawn off from the blood, they are thin and watry, yet by stagnating where they are deposited, the watry part being either evaporated into the air, or re-absorbed by the inhaling vessels in the containing receptacles, the oily inflammable part chiefly remains. Of this kind is the bile; (for the bile, when dried, is all inflammable, as likewise are the stones of the gall bladder;) the wax of the ears; the sebaceous secretions every where, as in the skin, eye-lids, &c. the fat all over the body, and the marrow of the bones. Milk, as it contains butter, is likewise akin to, and may be ranged under this class.

Now, as we have shewn in the former lecture, that there is in the blood a large quantity of elementary water; that it's serum is coagulable by the fire, and by alcohol; and that the whole blood, besides it's vehicle water, and besides oil, likewise contains salt, and earth, it is not difficult to see that there is the matter of all these secretions originally existing in the blood. But how it is brought about, that there are in different parts of the body, different liquors drawn off from the same mass, is what remains to be explained.

As many of the secretory organs in the body are to be particularly considered in their proper places afterwards, and their respective secretions more minutely

nutely examined, we shall at present only exhibit LECT.  
the general fundamentals of this doctrine. IX.

And first let us keep in view, that the red globules are the largest of all the particles that constitute the blood. From this position it follows, that every vessel or canal, that arises immediately from an artery containing red blood, which vessel or canal does not contain red globules itself, must necessarily be of a narrower diameter, than that of the artery it arises from, otherwise red globules could not be excluded. This is so evident, that it needs no explanation.

It likewise no less clearly follows, that every secretion is, in the instant of time it is separated from the blood, thinner, more watry, and fluid than the blood itself.

But you will ask, whence it is then that some secretions are thicker and more viscid than the blood? I answer, by the watry parts being drawn off after their separation from the blood, either by evaporation, if exposed to the open air, as the wax of the ears, or the mucus of the nose; or by re-absorption through inhaling vessels in the ducts or cavities, where they are some time detained; while the grosser are left behind, and being deprived of their fluid vehicle, form new cohesions, and grow thick. Thus the *semen*, by passing very slowly through a long tract of excretory canals, and at length stagnating in the *vesiculæ seminales* till the next venereal act, becomes thick, the humidity being absorbed in it's progress, and while it remains unexcerned. And hence in the incontinent it is of a thinner, and in the chaste of a stiffer consistence.

The qualities of the secreted liquors will vary chiefly according to the following circumstances.

1st, According to the different diameters of the secretory tubes that immediately separate them from the blood. The very smallest can admit only the thinnest fluids; and the largest can receive the



LECT. IX. groffest particles next to the red globules, and along with them all the other more minute ones. This is so evident, as to require no explanation. The largest secretory vessels seem to be those which strain off the oil or fat; and the smallest those of the brain and *cerebellum*, which separate the nervous juice or animal spirits.

2dly, A different quality of the blood that arrives at the place of secretion, other circumstances being alike, will afford a different secreted liquor. Thus the blood, which comes from the *vena portarum*, being from it's communication with the veins of the omentum fraught with oily particles, and being penetrated with the half putrid *miasmata* of the fæces in the thick guts from the meseraic veins, yields an oily secretion, inclining to rancidity. The mammary arteries in a nurse, being replete with chyle, afford a secretion very little different from chyle; for such milk is.

3dly, A greater or lesser velocity, or, which is the same thing, a greater or lesser force with which the blood is impelled into the secretory organ, will affect differently the secreted liquor. A greater force will render it more dense and ponderous, because it's particles will be more compacted and pressed together in the secretory organ; and likewise because the more ponderous particles will obey the direct impulse more truly, and pass into it in greater abundance: it will likewise render the secreted liquor more impure, turbid, or heterogeneous, as hard squeezing drives a more turbid liquor through a strainer, than a mild and moderate pressure would do. And hence in violent fevers, secretions are wonderfully perverted and confounded.

4thly, Which is the last head we shall mention, secreted liquors differ according to the different apparatus and contrivance of the secretory organ: under which I comprehend not only the structure of the organ itself, but likewise the circumstances of

of the blood vessels at their arrival at, and entry into it. It is one of RHUYSCH's principal discoveries in the human structure, that the small ramifications of arteries are constantly distributed in a different manner to different viscera. In some they are branched out like trees, in others they shoot out from a center like stars, or are laid close by one another like hairs in a pencil, &c. This being the common course of nature, no doubt answers a wise purpose, as every physical cause produces a determined adequate effect; though we are not always clear sighted enough to perceive it's ultimate tendency; much less duly to estimate and weigh the quantity of it's merit and influence. LECT. IX.

The different structure of the secretory organ must have an immediate principal effect upon the secreted liquor. If it is intended to be thick, it is deposited in cells or little cavities, where the watry parts may either be evaporated or re-absorbed, as in the instances we have given of the *mucus*, and wax of the ears. If it is designed to be thin, it is constantly pouring out, and flowing to it's destined place, as urine is into the bladder, &c. But we shall have occasion to shew this more at large, when we come to treat of particular viscera.

This may serve at present for a compendious view of the general doctrine of secretion; in the delivering of which you will no doubt wonder, that I have not once mentioned the word gland. This I forbore doing hitherto, chiefly for two reasons; first, because the greatest secretions of the body are performed without the intervention of any such contrivance or structure, as the appellation of gland was ever bestowed on; as the secretion of the fat, the Sanctorian perspiration, and the lymph. HALLER likewise, and very justly, reckons nutrition a general secretion. All these secretions are brought about by the simple mechanism of lateral tubes, of determined diameters, arising from larger

LECT. larger ones, without any peculiarity that hath procured the name of gland or glandular contrivance.

IX. Secondly, gland is a vague term, and taken in different senses by different authors; and therefore I was willing first to explain the doctrine of secretion before I used it, and afterwards to deliver what is fit to be known concerning the different significations of that word, and concerning some disputes that have arisen amongst authors about secretion.

The word *ᾄδνη*, which hath been translated in Latin *glandula*, in English gland (which probably comes from *ᾄδω*, *satio*; *quia glandulae sunt succulentae, et videntur quasi humore satiari*) was used by HIPPOCRATES, and other Greek authors, to signify certain parts of the animal body, distinguished from all other by a peculiar habit or appearance, more easily conceived than expressed, without regard either to their circumscribed figure, or use in the animal œconomy, as HEISTER hath learnedly and acutely observed. The English word kernel, when applied to animal substance, seems to convey precisely the same idea.

As several of these parts, called *ᾄδνες* by the ancients, were found to separate some liquor from the blood, as the kidneys, salivary glands, &c. the term *glandula* or gland came in use frequently to denote a secretory organ. At the same time such parts as were not known to yield any secretion, and yet called glands by the ancients, still retained their old appellation; as the thymus, thyroid, pineal, pituitary gland, &c. while other parts, which were allowed by all to serve solely or chiefly for that purpose, had not the name of gland bestowed upon them, as the liver and brain.

This bred confusion amongst authors, and different inconsistent definitions of the word gland were given: to avoid which we have framed one, which we apprehend is commodious enough, in the introductory lecture, and shall repeat it in substance



stance here. By a gland, we mean an organical structure of a peculiar kind, and circumscribed figure, the use of which is, or is supposed may be, to separate from the blood a liquid unlike to, and different from the blood. L E C T. IX.

By this definition is excluded, first the simple apparatus of secretion; such as, for example, is used to separate the fat, where there is no peculiarity of structure, nor circumscription of figure: and, secondly, such parts are excluded, as are acknowledged universally to separate nothing from the blood; for instance, the spleen. These, whose use is doubtful, may continue still ranged under the denomination of glands, as the glands of the mesentery, the thymus, &c. But under it are included some parts which the ancients did not call glands, to wit, the brain and the liver; because they both separate a fluid from the blood, and are of a peculiar texture and circumscribed figure.

I propose this definition only, because it is convenient for the clearer comprehension of what follows. In science it is permitted to use terms in what sense we please, provided we fairly define them.

Glands in this sense of the word are of four kinds;

The first is the most simple, and is made up of a membranous hollow receptacle, commonly called follicle, receiving the secreted liquor from small secretory tubes opening into it's sides, and depositing it there, where it remains until it is sent out by a single excretory duct or orifice. Of this kind are those glands, which separate the mucous liquor throughout the respiratory and alimentary passages, and the sebaceous glands in the skin, eye-lids, and many other places. Nature uses this contrivance, where there is a thicker secretion required. For as there are arterial secretory tubes that bring the secreted matter into the follicle, so there are venous absorbent small vessels that suck up a part of the humidity,

LECT. humidity, and render what remains thicker. If  
 IX. they are exposed to the air, the thinner parts are  
 evaporated.

The second kind differs from the first only in this, that they have two or more of the original ducts united into one large common duct. This contrivance adds something to the stop in the follicle, and tends to make the secretion still thicker. It takes place in the glands of the urethra, and in some others of the sebaceous kind.

The third kind is called the conglobate, under which are comprehended such as consist of one single undivided secretory structure in their whole bulk, and by this characteristic are opposed to the

Fourth kind, which are called conglomerate. These are made up of a *congeries* of many secretory structures, of the same kind and mechanism, firmly connected together, and so making one whole. Each of these little structures, which are called *acini* (from some analogy they seem to bear to the small knots or stones in some kinds of fruits) have a separate excretory duct, which original ducts, in most instances of this kind, variously uniting together, at length form one large excretory canal.

Of the conglobate kind may be reckoned the thymus, thyroid gland, &c. and by the unanimous consent of anatomists, those glands in the mesentery, which receive the lacteal and lymphatic veins, are ranged under it.

Of the conglomerate class are the two great secretory viscera, to wit, the brain and liver; the salivary glands, the *pancreas*, the breasts, and kidneys.

Towards the end of the last century, MALPIGHIVS, a celebrated anatomist, who was the first that applied himself to examine closely the subtle and minute structure of the viscera, gave rise to a warm controversy concerning the structure of glands, and the

the manner of secretion in the third and fourth L E C T. species, especially the latter. He was of opinion, IX. that there is a follicle in the middle of every separate glandular *acinus*; and that all secretion is made that way, in the more compound glands, as well as the simple ones we have described. His chief argument was taken from morbid appearances. He thought that encysted little tumors of different kinds being found in the secretory viscera, afforded a proof that follicles pre-existed there in a sound state; and that obstruction and congestion of matter only distended them, and rendered them more conspicuous.

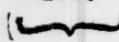
RHUYSCH was then coming into fame for his art of injecting, by which he filled minute vessels with amazing success, and demonstrated a vascular texture in numberless places of the body, where nothing of that kind was suspected to be before.

He, upon examining the preparations, where his injections had succeeded best, as in the kidney for example, where the injection passed from the emulgent artery into the ureter, found nothing but a congeries of vessels continued together, without any cavity or follicle intervening; and thence concluded, that the doctrine of follicles in compound glands was groundless and chimerical.

The great and deserved reputation of MALPIGHIIUS supported his doctrine almost universally for a considerable time against the single authority of RHUYSCH; who solely possessed the art of making the preparations he built upon, and studiously kept it a secret.

Even BOERHAAVE, who was an intimate friend of RHUYSCH's, and had access to see and examine his preparations, continued long a favourer of MALPIGHIIUS's doctrine. He thought that the filling of the arterial branches compressed the follicles, and rendered them imperceptible; and did not stick to hint as if RHUYSCH used some fraud to support his doctrine,



LECT. doctrine, by pressing and squeezing his preparations before the injection was quite cold, the more  
 IX.  effectually to obliterate every thing but the filled vascular texture.

At length, after seeing and considering more and more of RHUYSCH's preparations, he became more inclinable to close in with his way of thinking; and in this mood he wrote his celebrated epistle, *De fabrica Glandularum*, in which he, with great accuracy and strength, urges every argument that could anywise make for MALPIGHIIUS, with a view to prompt and spur up the old gentleman, who was not a little proud of his discoveries, and jealous of their credit, to support himself in the best manner he could. This letter had in a great measure the intended effect. RHUYSCH, though then fourscore and five, acquitted himself to admiration; and his answer made a proselyte of BOERNAAVE.

His doctrine hath continued to gain ground ever since, and now that the art of injecting is practised so universally, with a success little inferior to that of RHUYSCH himself; and even RHUYSCH's manner of preparing is published by ~~RUCER~~ <sup>Rieger</sup>, from his own manuscript, which he gave along with his preparations to the late great Czar, it is become general; all or most of the best physiologists rejecting follicles in the brain, liver, kidneys, and other glands, whether conglobate or conglomerate, and admitting only a texture entirely vascular. And indeed, since it is certain that some secretions are made without follicles, and since follicles cannot in these glands be demonstrated, common sense determines us to relinquish the doctrine of MALPIGHIIUS. *Entia non sunt multiplicanda sine necessitate; de non existentibus et non apparentibus idem esto judicium.* The arguments drawn from morbid appearances are easily answered. Obstruction and congestion of impacted matter, in a cylindrical distensible canal, may change it into a spherical

rical form, and therefore round morbid little L E C T. IX.  
 knots or tumors are no proofs of a pre-existent  
 follicle. The obstruction may be in the cellu-  
 lar texture, that in glandular viscera ~~by~~ the little  
*acini* together; and therefore such morbid appear-  
 ances do not necessarily interest the *acini* themselves:  
 and in effect they are ~~often~~ found where no gland-  
 ular structure is pretended to be, as in the placenta.

Before we dismiss this subject, we shall briefly  
 take notice of an opinion, which, however unrea-  
 sonable, gained considerable ground, and chiefly  
 amongst such as had, or would be thought to have,  
 a tincture of chemical knowledge; to wit, that  
 secretion is managed by the intervention of fer-  
 ments. By ferments they meant fluids at the places  
 of secretion, which being mixed with the secreted  
 fluid, in the instant of it's separation from the  
 blood, brought a chemical change upon it, either  
 in the way of effervescence, precipitation, solution,  
 coagulation, or otherwise; by which change it was  
 rendered of such a nature, and endowed with such  
 properties, as to be fit for the use intended. And  
 thus it was imagined secretions were diversified, each  
 different one having a particular ferment adapted  
 to it.

WILLIS was the chief broacher and promoter  
 of this doctrine, and French authors seem to have  
 been the longest fond of it. BOERHAAVE did not  
 stick to own, that there was a time when he inclin-  
 ed to that opinion himself; but he soon abandoned  
 it, and became the most zealous champion against  
 it; and now none of his school maintain it.

In the first place, the whole of it is mere fancy  
 and hypothesis; no ~~conclusive~~ experiment, that I  
 know of, having ever been brought to prove the  
 existence of any ferments within the area of the  
 circulation. On the contrary it hath been proved,  
 that the blood, and all the juices derived from it,

are

LECT. are neither acid nor alkali, nor effervesce with  
IX. acids or alkalies, nor with one another.

But even the possibility of their existence will not bear examination. If there were such ferments, they must be either furnished from the blood, and therefore be secreted liquors themselves, and so, according to the hypothesis, there would be still wanting other ferments to assist in their secretion; which would absurdly involve a *progressus* of ferments *in infinitum*:

Or they must be native and inbred in the animal, which is no less absurd; for how can it be granted, or even conceived, that any ferments, bred originally in the embryo, can hold out, and influence the secretions in the adult body so many millions of times larger, and that for four or five score years together?

Or, lastly, they must be supplied from the atmosphere without us, which if it be allowed, there is an end of all certainty in physiology; every liquor in the body may be said upon the same foot to come *ab extra*. And they who can acquiesce in such a supposition, may for me enjoy their credulity unmolested.

Since therefore no actual proof is brought of the real existence of such ferments; since that supposition is found to imply absurdities; and, lastly, since secretion can be explained without them, they are deservedly exploded by the most knowing physiologists; and it is one of the many glaring instances of the weakness of ~~the~~ human understanding, that so many men, in other respects acute and ingenious, should stand up for them.

For a more full and particular account of secretion, besides anatomists, who deliver the structure of the various glands, amongst whom HEISTER is by no means to be omitted, and besides BOERHAAVE and RHUYSCH's letters just now mentioned, I recommend chiefly BOERHAAVE's Institutions, and  
his



his Prælections upon them, published by HALLER LECT, with notes. HALLER's chapter on secretion, in his IX. *Prime Lineæ*, exhibits an excellent, compendious, but comprehensive view of every thing material relating to this subject; and with a proper commentary, such as I apprehend the author himself could give, would be much superior to any thing yet published. Innumerable authors have wrote professedly on secretion; but almost all of them serve more to perplex than instruct the student. KEILL, as he is short, may be looked into, but he is too prone to go into hypotheses. It is more profitable to read carefully, and digest a few good books, than wander and wade through a great many.

We shall conclude this lecture with a brief account of the two principal diseases that are peculiar to glands and glandular parts; to wit, schirrus and cancer.

Schirrus is a hard tumor of a glandular part, occasioned by the obstruction of the secretory tubes; often scabrous and unequal, especially when it possesses such glands as consist of pretty large *acini*; as the salivary glands, without pain at first, and often for ~~a good while~~ together; but in process of time shooting pains are felt in it, which when, they become remarkably uneasy and constant, denominate it cancer.

We have already shewn that every secretion is performed by secretory tubes, that are of too small diameters to admit red globules; and that compound glands, whether conglobate or conglomerate, are made up of a congeries or circumvolution of such tubes. These glands therefore must be very liable to obstruction, upon a double account; to wit, both upon the account of the exility of canals, and because these canals are complicated, and rolled up like clues; which will, *cæteris paribus*, increase the difficulty of transmitting liquids, and

~~long time~~  
many years

LECT. and render them apter to stagnate there than elsewhere. IX. Accordingly anatomists meet with unsurmountable difficulties, in injecting almost every glandular structure; but can push their coloured ceraceous matter into incredibly small vessels in membranous parts all over the body. Hence the frequency of schirrus is not to be wondered at.

The causes of schirrus are whatever either thicken the juices that are to pass through, or obstruct and render narrow the minute secretory tubes, so as to hinder their propulsion through them; and a resistance being thus caused to the progress of humors, tumor and hardness is produced.

Inflammation in a glandular part is often the antecedent cause of schirrus. Contusion likewise frequently produces it. But not seldom it is formed by a gradual infarction, without any preceding inflammation or fever.

When a schirrus is recent, resolution should be tried, it being then most practicable to bring it about, while the obstructing matter is most fluxile, and least firmly impacted: and for that purpose no stone should be left unturned. Inward dissolving medicines, outward discutient applications, if the part affected be within their reach, and a proper diet and regimen are to be most solicitously directed, that the obstruction may, if possible, be conquered, before it can have time to degenerate into cancer.

The most aperient vegetables, of which I take grass roots to be the chief; mild mercurial preparations, as æthiops mineral; antimony in different shapes, long persisted in, are principally effectual. Fresh whey in the summer time, especially sheeps and goats whey, is an excellent resolvent.

Fomentations made with emollient and discutient herbs; soap; the most dissolvent gums, as ammoniacum and galbanum, impregnated with quicksilver, are the best external applications.

Whatever

Whatever heats, dries and thickens, whether reducible to diet, regimen, or medicines external or internal, must be carefully avoided. LECT. IX.

When a schirrus is of some five or six, or at the farthest of twelve months standing, it is generally out of the reach of resolving methods, especially the quick and forcible ones, by mercury, or other mineral medicines. However, even then the gentle ways by whey, and cool aperient vegetables, may be safely tried.

When a schirrus becomes remarkably painful, it commences cancer, as hath been already said. The pain is caused by the acrimony and putrid state of the matter from a long stagnation, which begins to erode and destroy the containing vessels, and brings on a sort of slow inflammation at the margins of the obstructed parts.

While the integuments remain whole, and no matter is yielded by the affected part, the cancer is called occult.

But when there is a breach or opening made, and the tumor yields a fetid sanies or lee water, it is termed an open or exulcerated cancer.

An occult cancer, with the assistance of proper diet and prudent care, may be, and often is, born a long time, perhaps the whole remaining part of one's natural life. If a strict milk diet is in any case beneficial and necessary, it is here.

It is to be lamented, that there hath been as yet no remedy or method found out, which is sufficiently warranted by experience to be depended upon as a radical cure for confirmed cancers, whether occult, or open and exulcerated. Therefore the palliative cure, or extirpation, where it is advisable, can only take place.



## LECTURE X.

*Of the brain and nerves.*

LECT. X. **I**N the foregoing lectures, we have first described at large the action of the heart, and the motion, or circulation of the blood.

Next we explained respiration, as being the function most immediately connected with the circulation, infomuch that a born animal, that is furnished with lungs, cannot continue the motion of it's blood, for any remarkable space of time, not even many minutes, without breathing ; but must be quickly suffocated, and die.

Then we considered the nature and properties of the blood, and examined it first, as it appears to our unassisted senses, without much artificial apparatus ; 2dly, as it appears to the microscope ; and, lastly, as it is resolved into it's principles by chemical analysis.

As the heart is a muscular organ, it, like other muscles, owes at least a ~~great~~ part of it's action and energy to the nerves it is furnished with. And nerves being propagated from the brain, cerebellum, and their appendages, order required that we should next consider the functions of these parts.

Now the primary function of the brain being to separate a fluid from the blood, by the influx of which into the nerves the actions of these filaments are performed ; it was requisite to pave the way towards the understanding of the functions of the brain and nerves, by previously explaining animal secretion, and the structure and uses of glands.

And this we endeavoured to do in the last lecture. In which we shewed the following propositions ; to wit, that every liquor separated or secreted from the blood, was in the instant of separation thinner than the blood itself.

That

That some of the largest secretions in the body LECT.  
are made without the intervention of any structure X.  
or contrivance that ever had the appellation of  
glandular bestowed on it; as the fat, and Sanctorian  
perspiration; to wit, by simple lateral canals of  
suitable diameters.

That the most simple kinds of glands have fol-  
licles or membranous receptacles, in which the  
secreted liquors being some time detained, are ~~set~~ *sent*  
off to their destined places, by excretory ducts  
arising from these follicles; and that nature used  
this apparatus chiefly, if not solely, for the thick  
secretions, as the mucus, and the secretions made  
by these glands, called sebaceous.

That in the more complex, or compounded glands,  
whether these termed conglobate, or conglomerate,  
there is no good reason for allowing with MALPI-  
GHUS, and his followers, secretion to be performed  
by the intervention of follicles, as in the simple  
kind; but that the whole secretory structure in both  
these consisted of a vascular congeries, or convolu-  
tion, as RHUYSCH had ~~made~~ appear by his injections.

And, lastly, we exploded the ill grounded no-  
tion of fermentation in secretion.

We proceed now to treat of the encephalon;  
and shall first describe the structure of the parts,  
as far as is necessary to comprehend what we know  
of their uses and functions.

The aorta, or great artery, which issues a single  
trunk from the heart, is soon after it's origin bent  
backwards, and towards the left side, thus forming  
an arch; from the upper and convex part of which  
arise three large branches; the first of these, to  
wit, that on the right side, is quickly divided into  
two, one of which is called the right subclavian;  
the other the right carotid artery.

The left carotid, which is the second branch,  
arises from the same arch next to the right carotid.  
And the third branch is the left subclavian. The

LECT. two subclavians are chiefly distributed to the two  
 X. upper extremities; and the carotids to the head and  
 brain, and it's appendages.

The carotid arteries, ascending undivided as high as the larynx, are there split into two principal branches, called external and internal. The external is chiefly spent upon those parts of the head that are without the skull, and in it's neighbourhood, bating a pretty large branch it furnishes to the dura mater, and a small one to the cerebellum.

The internal carotid proceeding from it's origin straight, and without branches some way, at length makes a remarkable serpentine turn immediately before it enters the cranium, which it does through a particular hole in the os petrosum; from whence proceeding, and variously branching out, and anastomosing with the ramifications of it's fellow on the other side, and with the vertebals, of which we shall say more immediately, it furnishes different parts of the whole encephalon with arterial blood, and such liquids as are separated from it.

Besides these two arteries; to wit, the right and left carotids, the encephalon has other two bestowed upon it; to wit, the vertebals. They arise most commonly from the subclavians of their respective sides, and running through holes made for that purpose in the transverse processes of the vertebrae of the neck (from which course they have their name) they enter the skull at the great hole in the occiput, through which the spinal marrow passes, and are distributed to the encephalon, making, as hath been said, frequent inosculations with the branches of the carotids; and likewise with those of one another.

In this manner is the brain, cerebellum, and their appendages within the skull, which for brevity's sake I call the encephalon, supplied with arterial blood. And, if we consider the direct origin of these arteries from the heart, which must increase the



the velocity of the blood moving through them; LECT. and the largeness of their branches that enter into X. the cranium, we must be forced to own, that that portion of the blood, which is sent to the encephalon, is a considerable part of the whole that is thrown out by the left ventricle. MALPIGHIUS computes it at one third; and HALLER thinks it must be more than half that quantity, that is, more than a sixth.

It is probable that, upon the account of the directness of the origin of these arteries from the heart, the blood sent to the encephalon must abound, more than any other blood in the body, with dense particles, that retain their direct motion the most. The peculiar influence of mercury upon the head, vastly greater than upon any other part, appears a satisfactory proof of this position.

The frequent anastomoses of the branches of the four great trunks with one another, is a wise provision against obstructions, which, when they happen, prove so fatal here.

And the many bendings of the larger trunks, especially that large serpentine turn of the carotids before their entry into the cranium, may serve to moderate the impetus of the blood, which, without that contrivance, might be too violent for the tender and friable structure of the cortical part of the brain and cerebellum.

Having considered the apparatus of the arteries that go to the encephalon, we shall next take a view of it's situation, it's coverings, and it's structure.

In the human species, it is situated in the uppermost region in the body, man being designed by nature to walk erect; it was, therefore, most commodiously placed uppermost, that our senses, those of seeing and hearing especially, might have the largest scope of being exercised, not to mention innumerable other wise purposes, and the beauty and symmetry of the whole frame. In birds, the head

LECT. is likewise the highest part of the body. And in  
 X. most quadrupeds, whose heads must be with facility  
 bent so low as the ground to take their food, by the  
 motion of their necks the head may be raised sufficiently high above their trunk, to answer the purposes of their manner of living.

The encephalon is guarded by a strong bony covering, called the calvaria, cranium, or skull, to secure it from external injuries; it's structure being so delicate, that not only blows or contusions would destroy it, but even a compression, so gentle as not to violate the continuity of it's texture, is able to suspend, or pervert it's functions. This bony case is composed of eight different bones in the adult, and many more in the foetus, that the head and it's contents may grow, in proportion to the rest of the body.

It is covered by, or wrapt in three different membranes, of which two that were most early, and generally known, are called meninges, and matres, the dura and pia meninx, or mater, because they were reckoned the mothers or sources, from which all the other membranes of the body are propagated. The other being but lately discovered, is commonly called the tunica, or membrana arachnoidæa. We shall speak of each of them separately.

The most external, and the strongest of these meninges, or membranes, is the dura mater, so called from the hard texture of the fibres that compose it, they being stiff and tendinous-like, and even sometimes ossified. It serves to connect the bulk of the encephalon firmly to the cranium; and, by it's processes sinking into different portions of the brain, to keep all it's parts firm, thus preventing, in a great measure, the bad consequences that might arise from concussion, or violent motion; it serves as a firm basis, upon which the arterial and venous branches are spread, and fixt on their way to the brain;

brain; and it furnishes a strong external covering LECT. X.  
 to the distinct chords of nerves, that arise either from the encephalon, or the spinal marrow without the skull. It is manifestly divisible into two laminæ; the exterior one serves as a periosteum to the inside of the cranium, into which many vessels from it are strongly implanted and fixed.

Contiguous to the dura mater, is the membrana arachnoidæa. This membrane was unknown till the times of VAROLIUS, who flourished in the sixteenth century, after VESALIUS and FALLOPIUS, and first discovered and described it. It is found to have no vessels peculiar to itself, RHUYSCH having never been able to make his injection penetrate into it, so as to shew any. It covers both the encephalon and the medulla spinalis, and even, as very nice anatomists pretend to have found, descends a considerable way farther down, along with the medulla spinalis, than the pia mater. It serves as a sort of interlining betwixt the hard dura mater, and the smooth and thin pia meninx, that the tender and pulpy substance of the encephalon may be the more securely guarded, and not too roughly pressed upon by the hard external covering.

The pia mater is the innermost cover of the encephalon, and immediately contiguous to it. It sinks into every furrow, and humours every inequality of it's surface, either in the brain, cerebellum, or spinal marrow; and gives sheaths to the minutest perceptible nerves; so that it's surface is vastly greater than that of the other coverings. It is extremely vascular, as RHUYSCH's preparations demonstrate; and it is by it's intermediation, that the surface of the encephalon is supplied with vessels, conveying these liquids to it, by which it's functions are exercised, as it alone comes into contact with that surface all over.

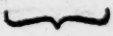
Having spoke of the coverings of the encephalon, we come next to consider it's particular structure.



LECTURE. But here we pretend to mention very little  
 X. more, than what bears some kind of relation to what  
 is hitherto known of it's general functions. As to  
 the peculiar uses of it's different parts, we know, or  
 can know little or nothing, with any tolerable de-  
 gree of certainty, of them. Nor could it be of any  
 use, to transcribe and repeat in lectures, minute ana-  
 tomical descriptions of extremely intricate organs,  
 which it is next to impossible for the hearers to  
 comprehend, unless the parts themselves were, at  
 the same time, leisurely demonstrated to them.

The encephalon, besides membranes, blood ves-  
 sels, and particular distinct chords of nerves, is  
 made up of two different substances; to wit, cor-  
 tical and medullary. The cortical (so called, be-  
 cause in the cerebrum and cerebellum, it is external,  
 and covers the interior parts, as bark is with respect  
 to the trunk or branches of a tree) is a soft pulpy  
 substance, the most tender and incompact of all the  
 parts of the body; of a cineritious, or ash colour,  
 with a dash of something between a faint red and  
 yellow. It is to this cortical part that the infinitely  
 small branches of these arteries, we mentioned as  
 supplying the encephalon, are first distributed by  
 means of the pia mater; and, therefore, this cortex  
 is, with good reason, held the secretory or glandular  
 part of the encephalon.

The medullary part, so called, because it is in-  
 terior to the cortical part in the cerebrum and ce-  
 rebellum, as the medulla, or pith of a tree, is within  
 it's cortex or bark, is white as snow, more hard and  
 compact, and less tender and pappy than the cor-  
 tical part. It arises every where from some portion  
 or other of cortical part, without any intervening  
 dissimilar substance; and, therefore, as there is good  
 reason to believe the cortical part to be the secre-  
 tory structure, so it is judged highly probable that  
 the medulla is the excretory part; and that it is  
 composed of hollow tubes, continued from the ves-  
 sels

sels of the cortical part; though so infinitely small LECT.  
and subtle, that no cavities can be discerned in them, X.  
even by the assistance of the finest microscopes, or   
most successful injections.

It is from this medullary part that all the nerves in the body are propagated; they being, beyond all doubt, a continuation of it's substance, digested into distinct chords or filaments, greater or smaller; strengthened or kept together by productions, as so many *vaginulæ* or sheaths of the meninges of the brain.

This is a rough draught, or the outlines of the nature and functions of the encephalon, considered in the gross. But we shall take a more particular view of it.

The principal parts of the encephalon are the brain, or cerebrum, strictly so called; the cerebellum, and the medullary productions of both.

The brain, or cerebrum, fills the greatest part of the cranium, reaching from the forehead to the *os occipitis*, under which the cerebellum lies, which is not above a fifth or sixth part of the largeness of the brain. The medullary productions of both possess part of the lowermost space of the cavity of the cranium, and at length uniting, form the spinal marrow; which passing through the great hole in the occipital bone, descends within the long cylindrical cavity, formed by the series of all the *vertebræ*.

The brain is of a figure, in some measure spherical, or rather like the half of an elliptical spheroid, cut through it's shortest axis. All it's exterior part, except a portion of its base, where it's medullary appendixes rest immediately upon the skull, is cortical for some considerable thickness, and is furrowed by irregular winding risings and depressions, resembling, in some measure, the convolution of the intestines of a small animal, in their natural situation; into every which depression, or furrow, the  
pia

LECT. pia mater sinks, and touches by close immediate  
 X. contact, the surface of the cortical part; in every  
 minute point implanting it's infinitely small ramifications of vessels into it, and adhering to it by that implantation. Wherever the cortical part terminates, there the medullary part begins, without any dissimilar substance intervening, as we have already said. And the cortical part being of different thickness in different parts, in a manner seemingly irregular, yet so as that the right side is, in its corresponding parts, perfectly similar to the left; there is a seemingly irregular mixture of cortical and medullary substance in the greatest part of the brain.

Again, as the figure of the encephalon must be nearly spherical, both upon the account of efficient and final causes, that is, both by it's manner of growing; to wit, from the center to the circumference; and to answer properly the purposes of life, when the form is completed; for it would be highly inconvenient, as well as uncomely, to have a broad flat head, like a cake; or a long small one, like a stick; therefore, in the brain, which is the far greatest part of it, the cortical part being exterior, the medullary part, which arises from it, cannot all tend regularly to the center, but must be variously reflected; and there must needs be a various mixture here and there of cortical and medullary substance, to fill up regularly and uniformly the globular space; and to give an opportunity both of sending off the nine or ten pairs of nerves through proper holes of the cranium, regularly to the right and left side; and of collecting together the main body of the medullary part, in order to be sent out by the great hole of the os occipitis to the spine. Upon both these accounts, windings and convolutions of the medullary substance, and a mixture up and down of cortex and medulla, were indispensibly requisite.

More.



Moreover, as the encephalon, of which the brain, L E C T. X.  
 strictly so called, is, as we have observed, the far  
 greatest part, is a large thick viscus, in the human  
 species weighing four or five pounds at least; though  
 a very great quantity of red blood is sent to it by  
 four large arterial trunks; to wit, the two internal  
 carotids, and the two vertebrals; yet little or next  
 to nothing of that red blood penetrates it's sub-  
 stance, either cortical or medullary, as it reaches no  
 farther than the pia mater, inclusive. Upon this  
 account the medullary part must be, in it's own na-  
 ture, cold, if compared with other viscera, which  
 are much more plentifully irrigated with red blood;  
 the motion of which through it's vessels, and the  
 attrition arising therefrom, being the principal, if  
 not the sole cause, of animal heat. To make up  
 this deficiency, nature hath furnished the brain with  
 ventricles: and, indeed, the necessity of a convolu-  
 tion, or winding, of the medullary part, not only  
 favours, but, in some measure, requires the forma-  
 tion of such cavities. Of these the two called ante-  
 rior, are very extensive, and wind in such a manner,  
 that there is hardly any medullary part of the brain,  
 at a remarkable distance from the walls of one or  
 other of them, as they are fellows, one on one side,  
 and another on the other. The other two, called  
 the third and fourth, are single in their kinds, and  
 very small in comparison with the two former. The  
 third is formed by a kind of mechanical necessity,  
 being a furrow arising from two round medullary  
~~vesicles~~, called *thalami nervorum opticorum*, ap-  
 plied to one another. The fourth ventricle is such  
 another furrow, between the medullary productions  
 of the brain and cerebellum, as they are going to  
 be united. All these ventricles in some measure  
 communicate with one another. The two larger  
 ventricles, where they approach nearest to one an-  
 other, are separated only by an extreme thin par-  
 tition, called *septum lucidum*, or, more properly,  
+ tubercles  
pel-

LECT. *pellucidum*. And even in one place it hath been  
 X. observed, that flatus may be transmitted from the  
 one into the other, without violating the septum.  
 They both communicate with the third, as the same  
 series of plexus choroides (of which more just now)  
 is continued through all the three. The third evi-  
 dently communicates with the fourth. And the  
 fourth opens into the cavity of the cranium, re-  
 ceiving by that aperture it's portion of the ~~procoffa~~  
*plexus* choroides, and is continued to a like furrow, that  
 runs down the medulla spinalis.

These ventricles are all lined with a fine smooth  
 membrane, which is, no doubt, a continuation of  
 the pia mater. And, as in all cavities of the body,  
 there is likewise in them a warm vaporous halitus  
 moistening their insides, hindring them from grow-  
 ing together, and at the same time serving, in some  
 measure, to cherish and warm them. But the prin-  
 cipal accession of heat is from the plexus choroides  
 we have mentioned, which are clusters of vessels  
 carrying red blood, both arterial and venous, with  
 a mixture of round pellucid glands, like little hy-  
 datids. Their arteries are supplied from small  
 branches, both of the carotids and vertebrales, but  
 chiefly the latter; and their veins are all returned  
 into the fourth sinus of the brain.

There is a cluster, or clusters, more or less, of the  
 plexus choroides in every ventricle, and they must  
 of course add to the heat of the ventricles and ad-  
 jacent medulla, as they carry red blood, and likewise  
 add to the moist vapour in these cavities, contri-  
 buting both to the bringing in and resorption there-  
 of, as they consist both of arterial and venous  
 canals.

But, though we have called the ventricles cavi-  
 ties, we must not think that in the living sound  
 body, there is any remarkable hollow space left be-  
 tween their walls. They are always contiguous to  
 one another, as the pleura and lungs are, except  
 where

where the plexus choroides fills up the space be-  
twixt them. But there is a moist vapour within,  
that hinders them from growing together: the ca-  
vity of the cranium is filled up completely by the  
encephalon in every part of it's solid content.

LECT.  
X.

In cutting through different portions of the me-  
dulla, we meet with red specks up and down, which  
shew blood vessels distributed amidst it; these, no  
doubt, contribute somewhat to add heat to it, though  
they are both small and rare.

The cerebellum hath, in common with the brain,  
a cortical part outwardly, which terminates variously  
in medullary tracts. And sections of it represent a  
beautiful mixture of both substances, the medul-  
lary part appearing not unlike trees sending forth  
branches. But it hath no ventricles within its glo-  
bular frame: probably, because it being not so large  
and thick, there is not the same occasion for them.

We have said, that the brain and cerebellum join  
their medullary substance together; and that this  
united mass or bundle, after nine or ten pairs of  
nerves are sent off through different holes in the  
skull, at length constitutes the spinal medulla, which  
passes through the foramen magnum of the os oc-  
cipitis, into the cylindrical cavity of the spine. We  
shall briefly describe the manner in which this  
junction is made.

The cortical substance on the outside of the brain,  
terminates variously into medullary portions, which  
tending towards it's middle, form the centrum ovale.  
This is the interior part of the brain, concentrical  
with the external convex surface, and of a similar  
figure, and, therefore, somewhat oval. It is all,  
or most of it, uniformly medullary. In the middle  
of it is formed the corpus callosum, being the me-  
dullary substance of the upper part of the brain,  
firmly united. From this arise the fornix, and the  
pedes hippocampi. The bulk of the inferior and  
lateral part of the brain, hath it's medullary part



LECT. collected into two crura, one on each side, the beginning of which are the corpora striata, and thalami nervorum opticom : to these crura the productions of the corpus callosum join themselves. The crura, at first distinct and separated, approach nearer as they go on, and uniting, form the medulla oblongata. So that the upper, lower, and lateral parts of the brain, have their medullary substance all collected and united in the medulla oblongata, excepting that part of it which furnishes the nerves already sent out of the cranium, and some medullary fibres, which are observed to go straight, to be joined with the origin of the medulla spinalis, without touching at the medulla oblongata.

In the cerebellum, things are more simple and plain. It's medullary substance is fairly traced, going in different pedunculi, or productions, to be united partly with the medullary part of the brain, before it is collected in the medulla oblongata, partly with the medulla oblongata itself, and partly with the spinal marrow.

But it is to be observed, that the medulla oblongata, and it's protuberances, and likewise the medulla spinalis, though they appear all medullary without, yet have cortical substance within, more or less, in different places.

Before we conclude, we shall take notice in what manner the various blood is returned from the encephalon. In the first place, the large veins pass through the cranium, not by the same holes the arteries enter, except a vein on each side, that accompanies the internal carotid. This appears a wise provision of nature, that upon violent motions, or in fevers, when the circulation is extremely increased, the arteries being distended, may not compress their fellow veins, and so occasion an accumulation of blood in the encephalon. Secondly, besides veins of the common structure with cylindrical cavities, there is a particular sort framed here, to be

be found no where in the body but in the encephalon, and medulla spinalis; whose sections, instead of being circles, are curvilinear triangles: these are called sinuses. Their walls, or coats, are formed by duplicatures of the dura mater, they running between the two folds of that membrane, and, therefore, are stronger and more elastic than veins of the common sort, and fitted to maintain their prismatic shape, and resist laceration and rupture. This contrivance can never be sufficiently admired. As a circle of all plain figures, contains the greatest area in proportion to its circumference, and particularly much more than a triangle, so a cylinder hath more solid content than a prism, other circumstances being equal. If, therefore, we suppose a prismatic canal, with its walls, in some degree, flexible, and a fluid impelled through it, with a force sufficient to change it's figure, the more the figure is changed, and the nearer it approaches to a cylindrical form, the more fluid it will contain. And this is the use of the sinuses. In violent motions, or in fevers, when the circulation is much increased, the blood returning by the small veins of the encephalon, will be poured into the sinuses with greater force and velocity; and, from the nature of fluids, will change the prismatic cavities into such as approach nearer to cylindrical; the flexibility of their walls allowing that change, in proportion to the force of the impulse, and the compressibility of the encephalon admitting the increase of the capacity of the prismatic canals. So that the more rapidly arterial blood is poured into the encephalon, and the more it's structure is in danger of being hurt by that rapidity, the wider will the canals become that carry it off. In so wonderful a manner doth the supreme Author of nature geometrize! Their elasticity serves to recover again their prismatic figure, when the impulse is diminished. Their strength secures them against rupture.

There

LECT. There are many such sinuses in the brain : but

X. anatomists have too much multiplied their number.

— The appellation of sinus should be restricted to those who have triangular sections. The most remarkable are the longitudinalis superior, which runs immediately under the sagittal suture ; the two laterals, with both which the longitudinal communicates ; and that called the fourth, which opens into the laterals at the same place with the longitudinal. The place where all four meet is called *torcular Herophili*. The whole veins of the encephalon open into some sinus or other. All the sinuses terminate ultimately in the lateral ones ; and they pour their blood into the internal jugulars, to be quickly sent into the vena cava superior. The medulla spinalis is likewise abundantly supplied with sinuses.

The best particular treatises on the brain, are those of WILLIS, VIEUSSENS, and RIDLEY, which with systems of anatomy, that we cannot be without, are sufficient to the student for the anatomical part.

## LECTURE XI.

*Of the brain and nerves.*

LECT. XI. WHEN we were last together, I discoursed on the encephalon, and laid before you the

— substance of what I apprehended was requisite to be premised to an account of it's uses and functions, as far as they are known with any tolerable degree of certainty. A more minute detail of it's intricate structure, would be puzzling rather than useful here ; it's proper place being in courses or books of anatomy.

After describing the arteries, by which it is supplied with blood from the heart, and the three membranous coverings it is wrapt in, we observed in general, that the proper structure of the encephalon consists of two different substances ; to wit, the

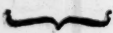


the cortical and the medullary; the former of a LECT. XI.  
 pale red colour, with a faint yellow cast; the most  
 tender and pappy of all the parts of the animal  
 body; the latter white as milk, harder, drier, and  
 less pappy; we remarked that, the cortical part  
 being exterior, the extremely fine and subtle rami-  
 fications of the arteries, sent to supply the encephalon,  
 are implanted in it by the intervention of it's  
 innermost covering, the *pia mater*; and that the  
 medullary part is every where immediately continued  
 to, or, which is the same thing, arises from  
 some portion or other of the cortical substance.  
 From which we, by way of anticipation, concluded,  
 that it is highly probable the cortical part is the  
 secretory, and the medulla the excretory organ of  
 the encephalon.

Then we took a more particular view of the different circumscribed masses, that make up the whole of the encephalon; to wit, the cerebrum, or brain, strictly so called; the cerebellum; and the medullary productions, or crura, of both. We found the cerebrum far exceeds the cerebellum in bulk, and that it is furnished with cavities called ventricles, within it's globular frame, which the other wants, and we endeavoured to point out their use.

We observed, that both the cerebrum and cerebellum consist of an exterior cortical part, terminating in medulla; and that the medullary productions of both are united together in the medulla oblongata, and spinalis; which last passes out of the skull, through the great hole of the os occipitis, into the bony cylindrical case, formed by the vertebræ. But we took notice, that there are nine pair of nerves arising from the medullary part of the encephalon, before the origin of the spinal marrow is formed, which are sent out of the skull through particular holes.

And, lastly, we carefully considered, and accounted for, the wonderful contrivance of sinuses, to

LECT. return the venous blood from the encephalon, in the most advantageous manner. We proceed now  
 XI.  to take into consideration the uses and functions that result from this structure.

We cannot help here giving entirely into the most generally received opinion of physiologists, however strongly it is controverted by some; to wit, that by the subtile vascular texture of the cortical substance, there is strained off, or secreted from the arterial blood brought to it, a fluid or liquid, the finest, most attenuated, and most moveable of all in the animal body; and that this liquid, by it's flux through the medullary fibres, which we hold to be the excretory ducts of the cortical part, and through the nerves (which are evidently the continuation of the medullary substance, distributed into distinct chords or cylindrical bundles.) I say, that this liquid, by it's motion through the medullary and nervous canals, is the immediate corporeal cause, or *conditio sine qua non*, in the living animal body, of sense, perception and thought, and of voluntary muscular motion: so that the cortical part is the secretory or glandular structure, but without follicles, of the encephalon, and the medulla and nerves it's excretory canals, containing and transmitting the subtile and moveable liquid just now mentioned.

There is no position in the whole compass of physiology, that, within this half century, hath occasioned warmer disputes than this. But, without derogating from the merits of those who have opposed it, I think I may venture to say, that a great majority of such as have applied themselves to the study of the animal machine, with the greatest diligence and candor, as well as the greatest success, have maintained, and still continue to maintain the affirmative, notwithstanding all the objections against it.

The limits of this course will not permit us to present a very comprehensive view of the controversy:  
 verily:

verly: to do so ~~might furnish materials for a large~~ L E C T. volume. We shall only lay before you a few of XI. the strongest arguments for it, and examine some of the most weighty objections brought against it.

And first then, let it be considered that the texture of the cortical part is vascular, it's vessels being continuations of those in the pia mater, which are implanted in it.

This RHUYSCH has made evident by his preparations. After a successful injection of his ceraceous matter into the carotid arteries, he found the cortical part of the brain become red in different places; for he could never penetrate through the whole of it: then separating a red portion of it from the rest of the brain, but cohering with the branch of an artery, and macerating it in water, till the membranes putrefied and dissolved off, he put what remained in spirits of wine, and found it to be a red, very tender, flacculent, or fleecy coherent substance, which could be no other than the vessels of the cortical substance, filled and tinged red as far as the injection had reached; the oily nature of which had hindered it from being dissolved in the water, as the membranes, and other parts that were not filled had been. Such preparations RHUYSCH often made, and found the experiment to succeed in like manner with the cortical part of the cerebellum, medulla oblongata, and spinalis.

So that here we see a vascular structure in the cortical substance; and, if the injections pervaded not the whole of it, we ought rather to conclude, that there are canals continued to, and arising from the largest sort, which are too small and subtle to receive the ceraceous matter, than that the vascular texture ends where the injection can go no farther.

LEWENHOEK's observations justify this conclusion. By his microscope, he finds blood vessels propagated from the pia mater, and sinking some way into the cortical part of the brain, though with



LECT. few red globules in them; and smaller fibres, as he  
 XI. calls them, arising laterally from these blood vessels,  
 which, no doubt, were canals of narrower diameters\*. And, in another place, he finds a chrystalline or limpid fluid dropping from these fibres; in which fluid there were particles some hundred times smaller than red globules†.

Now we have shewn, that in every systole of the heart, a very great quantity of blood is sent to the encephalon, by four large arterial branches; to wit, the two internal carotids, and two vertebals; which run pretty directly upwards from the heart, and, therefore, the blood being moved through them with a considerable velocity, must arrive at the cortex cerebri in large quantity, in proportion to the given time. MALPIGHIVS (as we have said) estimates it at one third of the whole that is thrown out by the left ventricle; and HALLER thinks it must be, at least, one sixth. We shall take the least proportion. Let us suppose, that the quantity thrown out by the left ventricle, at every pulse, is an ounce and a half, which is a low value, as the exactest and latest measures of the capacity of the ventricle, run from two to three ounces. A sixth part of this is a quarter of an ounce. Let us take the number of pulses to be 60 in a minute, or 3600 in an hour, which is a very slow pulse. By this estimate, 900 ounces, or six pounds and six ounces, must arrive every hour at the cortical part of the cerebrum and cerebellum, which amounts to above 110 pounds in the natural day, or 24 hours.

As so great a quantity of blood arrives at the encephalon in so little a time, (and, though it were taken double, there would be no great exaggeration of the matter) is it to be supposed that there is not a large constant secretion made here, since the cor-

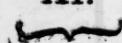
\* Epist. Physiolog. 34.

† Anatom. & Contemplat. 1. pag. 30, &c.

tical part is evidently found to be vascular? And, LECT. XI.  
as the medullary substance is plainly a continuation of the cortical, without the interposition of any dissimilar structure, is it not a natural inference to conclude, that as the cortex is the secretory, so the medulla is the excretory part? Can it be reasonably imagined, that such a large quantity of blood, after arriving at the cortical part, or, if you please, at the beginning of the medulla, meeting with this impervious obstacle, is beaten back and returned by the veins and sinuses, without sending off some considerable part of it through the medulla. This argument is not a little strengthened by the consideration of the structure of the medulla, which is found to be not a pulpy confused mass, but composed of distinct fibres, lying parallel by one another. This even the naked eye may discover, in several parts of the human brain, in the corpus callosum, for example. In the brain of some fishes, it appears still more clearly: and LEWENHOEK's microscopical observations abundantly confirm it. So that the medullary fibres may be, and, I think are, distinct tubes, answering and continued to the minute vessels of the cortical part, though so fine as that no cavity can be discerned in them, even with the assistance of the best microscope.

But farther, the cortical and medullary parts and the nerves, which are most evidently a continuation of the latter, grow and are increased in all their dimensions, in a constant proportion, though not the same at different ages, till the animal hath arrived at it's full stature. Is not this a demonstration, that the medulla and nerves are tubular, as well as the cortical part? and that their accretion is owing to the common cause; to wit, the force of the heart, and the propulsion of liquids thereby effected, distending and lengthening all the tubes of the body, while they are pliable enough to obey it's impulse. Is there not the same reason for thinking so with

LECT. respect to the medulla and nerves, as with respect  
 XI. to the hands and feet, the legs and arms? BOER-

 HAAVE is of opinion, that this argument scarce yields, in point of strength, to the testimony of our senses; and his illustrious disciple HALLER, thinks an honest mind can hardly find a subterfuge to elude it. And well might they venture so to declare: for, if we attentively consider the marvellously complex and intricate structure of the encephalon within the skull, it's labyrinths, it's tubercles and depressions, the constant certain mixtures of cortex and medulla, the manifold, though regular, medullary productions great and small; the sending off many pairs of nerves through different holes in the cranium, and the bulk of the medulla into the cavity of the spine; and, lastly, the inextricable and endless ramifications and distributions of the nerves through every part of the body, till they become so small as to elude not only the knife, but even the armed eye: and if we consider, at the same time, that in a new-born child, this structure is of the same form, and consists of the same various parts as that of a grown-up man, though it be at least less, by one half, in every dimension, and, therefore, contains eight or ten times less matter, we must, I think, either give ourselves up to an unaccountable and culpable scepticism, or conclude, that this perfect and thorough accretion could not be brought about, as nature is now constituted, if the medullary fibres, which we have shewn to be distinct from one another, are not tubular, but solid, and without regular cavities.

These are some of the most solid, as well as plainest arguments, serving to prove, that a fine subtil fluid is secreted by the cortical part of the encephalon; and that the medullary substance, of which the nerves are a continuation, is made up of the excretory ducts of the cortex, receiving and transmitting this fluid for destined purposes. And



as we look upon them to be satisfactory, we shall at present make use of this proposition as proved, and apply it accordingly to our enquiries into the functions of the encephalon. The principal objections against it shall be taken into consideration afterwards.

All of us feel that imagination, memory, judgment, and, in a word, every species or modus of thought, properly so called, and distinguished from simple sensation, is exercised chiefly within the head. It therefore follows, that the encephalon taken complexly, and at large, is the seat of these faculties.

And the whole of the proper structure of the encephalon, being cortex and medulla, it is justly inferred, that it's proper functions are immediately influenced by the various circumstances of the motion of this subtile fluid, through it's various parts, as a corporeal cause, or a *conditio sine qua non*.

Blood extravasated within the head; pus, water collected and accumulated; in a word, whatever presses in an unnatural manner upon the encephalon, and incroaches upon it's volume, more or less impairs and perverts the above mentioned faculties; which is a confirmation of this doctrine *à posteriori*. For the cranium being always completely filled with it's contents in a state of health, every considerable additional pressure upon them must, more or less, obstruct the freedom of motion in the liquids of the encephalon through their canals.

Experiments shew that nerves are the immediate instruments of sensation, and, likewise, that they are indispensibly requisite towards the exercise of muscular motion, at least the voluntary kind of it. If a large nervous trunk is cut through, or otherwise destroyed, both sense and voluntary motion is abolished in the part, to which it's branches are distributed, unless it be also furnished with other nerves. A ligature upon a nerve hath the same effect, and, when it is removed, both sense and

LECT. motion return, if the texture of the nerve hath not  
 XI. been ruined by hard tying. An obstruction of the  
 { optic nerves, suppose from a tumor, causes blindness, though all the parts of the eye be sound.

But in order to maintain sensation, the integrity of the nerve alone is not sufficient: a sound encephalon is absolutely necessary to concur with sound nerves. A strong fit of apoplexy, the cause of which lies within the head, takes away perfectly all sensation, as well as the other animal faculties, and leaves only the motion of the heart, and respiration. Therefore the foundation of sense lies in the encephalon, at least, a certain degree of it's soundness is absolutely necessary to sensation.

The causes which excite sensation being, for the most part, without the body; to wit, the objects of the five senses, and always external with respect to the encephalon, (for some are within the body, as local pains in distempers) physiologists have reasonably inferred, that sensation is produced by a reflux of the fluid moving within the nerves towards their origin, occasioned by the impulse of it's objects or causes: and, with respect to them, the mind or sentient principle, whatever that be, is passive.

In the exercise of voluntary muscular motion, it is no less natural to conclude, that the nervous fluid is, by an effort of the will operating in a manner instantaneously, sent from it's origin in the beginning of the medullary part, through the nerves, continued to it into the organism of the muscles: and, in this respect, the mind is active. But we shall consider muscular motion in a separate lecture.

With respect to the operations of the mind or soul, as consciousness, imagination, judgment, memory, passions, &c. it is reasonable to think that these are attended with respectively different motions of the fluid, separated by the structure of the cortical part through the various medullary tracts, tubercles, crura, &c. of the encephalon. We are con-

con-

conscious of exercising an infinite variety of thought; L E C T. XI.

we see the structure of the encephalon to be extremely complex and intricate; we are therefore authorized to draw the general conclusion just now mentioned, because nature does nothing in vain. But what the particular uses of this or that tubercle, process, or bundle, within the encephalon, are, we know not, and, I believe, never can know. The only possible way of throwing light upon these matters is, that of observation and experiment. Experiments made on brutes can stand us in little or no stead, as they are destitute of reason and articulate speech. Even those made on the live human species, could any be so impious as to attempt them; would, upon the account of the extreme difficulty in conducting them, and the tender delicacy of the parts, be so precarious, that very few, if any, certain conclusions could be drawn from them; and observations from opening dead morbid bodies, can shew but very little: nor, indeed, is such a knowledge necessary for practice.

So that what DES CARTES, WILLIS, and others after them, have pronounced concerning the uses and functions of the several parts of the brain, as they offer no satisfactory proof of what they advance, are to be looked upon only as idle notions and mere chimeras.

This fluid, which is secreted by the cortical part, and flows through the medullary small tubes of the encephalon, hath been called animal spirits ever since the days of GALEN. The name is highly proper, as it is, or at least is judged to be, the immediate active cause of the principal functions in the animal body; of these functions, by which the class of animals is distinguished from that of vegetables; to wit, sense and spontaneous motion. Modern authors have occasionally bestowed other appellations upon it, as *succus nervus*, nervous juice or fluid, *liquidum nervorum*, *liquor encephali*, &c.

Having



LECT. Having briefly laid before you some of the  
 XI. strongest arguments that are adduced to prove the  
 reality of such a fluid, we shall enquire next into it's  
 nature and constituent parts.

And first, it must be extremely thin and subtile. This appears from the nature of the cortical substance, that strains it off, and the medullary and nervous tubes, through which it moves. RHUYSCH, by his most successful injections, could never fill all the cortical part, much less affect the medulla. Nor have the best microscopes been able to shew cavities in the medullary or nervous filaments. LEWENHOEK, in his extreme old age, fancied he saw cavities in nerves, but the truth of that observation hath been universally disbelieved. See his *Epist. Physilog.*

Secondly, it must be extremely moveable. This is a consequence of it's great thinness and fluidity. A thin liquor, *ceteris paribus*, obeys every impulse more easily and quickly than a thicker one. It likewise appears from the celerity and rapidity of the functions influenced by it. Sense is excited immediately upon the application of the sensible object to the organ; voluntary motion is exercised immediately upon the exertion of the will; and the dullest of us are conscious of the unbounded swiftness of thought.

Thirdly, it must be of a mild quality, and perfectly free of every kind of acrimony that hath a tendency to hurt the delicate and tender texture of the canals it moves through.

Thus far every thing appears easy and clear, and can be denied by none that admit the reality of a nervous fluid or animal spirits: but it remains to enquire what substance this fluid consists of, and what are it's constituent parts. And concerning this question many different opinions have been entertained, and many chimerical hypotheses broached. Some have imagined it to be of the nature of fermented spirits; others have likened it

to those of the urinous and volatile kind. Some make it consist of aerial, others of luminous particles: and not a few of late have imagined it to be æther, or electrical matter. BOERHAAVE attributes to it an aqueous nature, without mentioning any other property. HALLER rejects every opinion that he found had been advanced concerning it's nature, and leaves the question undecided.

In the year 1740, I published a Latin poem on nervous distempers, entitled, *Neuropathia*; to which is prefixed an epistolary discourse in prose, explaining and enlarging upon some points relating to the principal subject, which could not be conveniently discussed in the poem itself. In this discourse, after having asserted the existence of a nervous fluid as a fundamental doctrine, and endeavoured briefly to take off Dr. CHEYNE's objections against it, I proceeded next to enquire into the nature and constituent parts of that fluid, and proposed a new opinion of my own, in words to this effect, "That such books  
" as I had read upon this subject did not give satisfaction; on the contrary, I wondered that an  
" easy and obvious manner of reasoning had not  
" occurred to their authors, to this purpose; to  
" wit, that as the animal spirits are the finest and  
" most subtle of all the fluids in the body, the  
" nerves must be nourished solely by these; it  
" being impossible for a canal to be nourished and  
" repaired by a fluid which is too gross to enter into  
" it. That therefore as nerves must grow and be  
" nourished, and kept in repair as well as the other  
" solids, the animal spirits must contain such principles as animal solids consist of; to wit, as chemistry teaches, earth, which is as it were the  
" basis; oil and water, which serve as a gluten;  
" and a certain salt peculiar to animals, mild and  
" neutral in it's own nature, but which is rendered  
" alkaline and volatile by distillation in a retort;  
" all extremely attenuated, and intimately mixed  
" to-

XI. “ together. That I was of opinion that not any  
 “ one thing, even in the elements of geometry,  
 “ more truly follows from data, than this propo-  
 “ sition from the existence of animal spirits being  
 “ granted.”

Agreeably to which persuasion I apply this doctrine in the poem to pathology, and build indications of cure upon it.

In the year 1751 I published a small treatise in English, digested in a geometrical form, entitled, *The Nature of the nervous Fluid, or animal Spirits demonstrated*, in which I endeavour farther to illustrate, prove, and establish the same doctrine, to which I refer you.

As I know not that any thing of moment hath been advanced against it, and as nothing has occurred to my own mind, that induces me to change my opinion, I cannot help still persisting in it, and subscribing to the Hippocratic maxim, *Corpus ipsum sibi ipsi idem est, et ex iisdem conflatum.*—*Corporis quidem pars minima omnia habet qualia quidem et maxima.*

We come now to take into consideration some of the principal objections that have been raised against the reality of this fluid, and against the tubular structure of the medulla and nerves.

The first objection is, that neither the fluid itself, nor cavities in the medulla and nerves, can by any artifice or preparation be made apparent to our eyes, though assisted by the best microscopes.

The answer is obvious; to wit, that this only proves our senses to be limited. There are many things, of the existence of which we are certain, that we cannot see. Even the effects of microscopes are limited. There are animalcules so minute, as to appear, when viewed through the best glasses, to be little bigger than points; but these must consist of a variety of organised parts, much less than their wholes. Why then may there not  
 be



be vessels in the human body so small that their L E C T. cavities cannot any how be perceived? Besides, the nervous fluid must, upon the account of it's defecated fineness and fluidity, be both transparent and volatile. The former quality renders it invisible, though it were possible to fix and arrest it; and the latter hinders it from staying till it can be viewed. XI.

It is not to be wondered that no cavities can be seen in the medullary and nervous filaments. When the transverse section of a nerve or medullary portion is viewed through a microscope, the canals must be collapsed for want of the vis vitæ continuing to urge the proper liquids through them, and keep them open, and by the dissipation through volatility of those that remained last in them. No injection can be made to reach them, and keep them distended: nor is it to be expected there should be. No injection hath hitherto been made to pervade the whole substance of the testis, which no doubt separates a much grosser liquor.

It is alledged, that in a living animal, a nerve, when tied, does not swell between the ligature and the encephalon, and therefore there is no regular flux of a liquid through it's fibrils from the head forwards. To which we answer with HALLER, that supposing the fact were strictly true, nothing can be justly inferred from it to prove what is intended; because, though there should be a fluid constantly moving through the nerve, it's motion may be so mild, as not to be able to raise the stiff dura mater, with which it is sheathed, into a sensible tumor, and yet operate powerfully at the ultimate termination of it's fibrils, where that covering is laid aside. But so it is, that a nerve, when a ligature is applied, hath been observed to swell somewhat, especially in younger animals. However, that tumor may be occasioned by the stop-  
page

LECT. page of liquids in the vessels of it's involucra ; and  
 XI. not in the proper medullary substance of the nerve.

So that, let the experiment succeed either way, nothing, as professor MONRO observes, can be rightly concluded concerning the matter.

Another objection, in which the opposers of our doctrine triumph and swagger not a little, is taken from foetuses, having been observed to be brought forth alive, and to the full time, without any brain at all ; and sometimes without spinal medulla, and nerves arising from it. But this argument, if it prove any thing at all, strikes against the use of the brain and nerves in general, and equally against every modus of their functions. In reality, all that can be inferred from it is, that a foetus, while in utero, may, without some principal bowel, which, after it's exclusion, is indispensibly requisite to continue vitality, grow and enjoy some imperfect kind of life, by virtue of the connexion between it and it's mother. But the manner in which sensation, perception, and spontaneous motion is carried on in the compleatly formed animal, is not in the least affected by such observations. Foetuses have been born without the heart : but does that destroy the doctrine of the action of that organ, and the circulation of the blood ?

The sticklers against the doctrine we are defending, almost unanimously agree in substituting in it's place a tremulous vibration of the medullary and nervous fibres, by which they endeavour to explain their functions. I am apt to believe that such an ill-grounded, out of the way notion had never entered into the human mind, as open as it lies to admit absurdities, were it not that the Latin word *nervus* signifies both a sinew or nerve, a part of the animal structure, and the string of a musical instrument, which evidently trembles when it excites sound. I do not find that the Greek physicians

sicians entertained any such opinion. Their word LECT.  
 answering to *nervus* is never used to signify XI.  
 chorda. }

Of all the solid parts of the human body, the nerves are the most unlikely to tremble upon any impulse; they are all moist, they are soft in their origins and terminations; and most of them are so far from being bent, that they lie loose and winding. The circumstances of a tremulous chord are the reverse. It must be hard, dry, and tense; it must be made fast at both extremities. Without these conditions it cannot tremble. Who can seriously believe that the retina, a soft mucous pulp, placed contiguous to a thin aqueous jelly, for such is the vitreous humor, is susceptible of a tremulous motion from impulses of the rays of light? Besides, if such vibrations were allowed for argument's sake to take place, however commodiously they might be supposed to explain sensation, they could by no means account for muscular motion; for what hath trembling to do with traction or pulling, with moving or raising of great weights? To acquiesce in an opinion so ill founded, and so easily overthrown as that which makes the action of nerves to consist in tremulous vibrations, argues either a gross ignorance of the animal structure; or, which is still more culpable, a supine or wilful inattention to it. But I am ashamed to spend more time in confuting a tenet so evidently and so egregiously absurd.

For a full view of this controversy, besides the physiological works of BOERHAAVE and HALLER, consult HEISTER in his Compendium of Anatomy, and the authors he refers to in his note; and MONRO's discourse on nerves in general, as added to the third and subsequent editions of his Osteology.



## LECTURE XII.

*Of muscular motion.*LECT.  
XII.

**A** Muscle is the immediate organical efficient cause or instrument of animal motion, whether voluntary or involuntary. I have said organical, because there are motions produced in the living body by mere elasticity; an instance of which we have seen in the cartilages of the ribs, and in the arteries.

The general characteristic, in which all muscles agree, which none are without, is to consist of fleshy fibres, which when acting, shorten and contract themselves.

This contraction, according to the different circumstances of the muscle, and the parts to which it is fastened, produces different effects, and different motions: if one end of a muscle is tied to a fixed part, and the other to a moveable one, it's fibres contracting, pull the moveable part towards that which is fixed. If both the parts, to which the extremities of a muscle is attached, be moveable, by it's action they will be both drawn towards each other. If the muscle is hollow, and contains a fluid, when it contracts it will press upon and endeavour to expel it's contents. If the fibres of a muscle return upon themselves in the form of a ring, when they contract, they must diminish the area within that circumference: such muscles are employed to contract apertures, and are called sphincters.

Most muscles, either at one end or both, have tendons, which are the fleshy fibres continued; they being divisible into as many fibres, or rather bundles of fibres, as the muscles are, to which they belong; but the tendinous fibres are smaller, more compacted, drier and harder than the fleshy ones. They are not capable of contraction; but serve like ropes

ropes to draw when the fleshy fibres act, for the L E C T. commodiousness and firmness of insertion, and for XII. the direction of motion. They are commonly of a white resplendent colour; while the fleshy fibres are of a cherry red.

That tendinous fibres are a continuation of the fleshy, appears in a good measure to the naked eye; but demonstratively from this consideration, to wit, that the nearer an animal is to it's origin or embryo state, the less tendinous it's muscles are; and *vice versa*, the older it is, the more so.

The whole muscle, both it's fleshy and tendinous part, is covered over with a cellular membrane, not without oil or fat in it's cells, more or less, according as the muscle is large or small, and according to the degree of motion it exercises. And this cellular membrane, as we have said in the introductory lecture, likewise sends off productions, which sheath over every lesser bundle of fibres, especially the fleshy ones, of which the whole muscle is composed, as far as they can be traced, which keeps them distinct from one another, hinders them from growing together, and renders them smooth and slippery, and fit for performing their respective motions and contractions.

Muscles are plentifully supplied with arteries, carrying red blood, which branch out into smaller and smaller twigs, till they seem lost, both in the cellular membrane, and the proper substance of the muscle. These arteries are accompanied with veins ramified in like manner, insomuch that a considerable part of the bulk of a muscle is owing to it's blood vessels; and the red colour of the fibres seems to be produced by the blood, which irrigates them; for when that is washed out by repeated injections of warm water, the muscle both becomes pale and shrunk.

Lymphatic veins are likewise observed in muscles.

M

And,

LECT. And, lastly, nerves are distributed to muscles in  
 XII. plenty, and soon become so small by their divisions, as to be past tracing.

Blood vessels and nerves are not wanting even in the tendons; but are there both smaller, and less numerous.

See every thing relating to muscles in general most accurately, fully, and elegantly described, as far as the eye, injections, knife, or microscope can go, in the first book of ALBINUS's Myology.

No one action in the animal body hath so much puzzled enquirers, as the particular manner in which muscular motion is performed; and no wonder, since anatomy serves us in little or no stead in our researches after it: we can neither reach the last divisions and terminations of the blood vessels and nerves, nor can we any how come at the ultimate structure of a muscular fibre. When we have used the greatest magnifiers to discover the texture thereof, we are no wiser than when we only employ the naked eye; we see nothing but smaller bundles similar to the larger ones, which they compose.

As therefore the truth cannot be made out by direct autopsy, authors have had recourse to fancy and conjecture. And, as it is much easier to demolish than to build up, to confute error than to find out truth, each writer on this subject, after confuting former hypotheses, which for the most part it was not difficult to do, thought it incumbent on him to propose a new one of his own, which was in it's turn confuted.

We shall, chiefly following BOERHAAVE and HALLER, but with some little variation of our own, lay before you what we apprehend to be most simple and probable concerning this abstruse matter.

It is certain, as hath been mentioned before, that tying a nerve fast round, cutting, or otherwise destroying



destroying it, immediately stops the voluntary LECT.  
action of any muscle, that is supplied solely with XII.  
filaments from that nerve.

Tying an arterial trunk, which furnishes a muscle with all it's blood, destroys it's action also; but not instantly, nor till some considerable time after; at least, several hours after. From which it may be justly concluded, that an actual present supply of arterial blood to the substance of a muscle is not requisite to every single exertion of it's contractile power. And it is natural to think, that an inability of moving, after the artery hath been tied a considerable time, is occasioned by the muscle's being thereby reduced to a state of mortification for want of nourishment; and so rendered unfit for obeying the influence of the nerve, whatever that may be.

And therefore every hypothesis, which requires a meeting or mixture of blood with the nervous fluid in the organism of the muscle, to produce every single act of muscular motion, must fall to the ground.

The belly of a muscle, (for so it's fleshy part is called) when the muscle is acting, swells, and becomes hard, as any one may perceive in his own body, (by putting his hand upon the masseter muscle for example, while the jaws are forcibly pulled together; or upon the biceps muscle, while the fore arm is forcibly bent.) This one would imagine denotes, that there then is an additional influx of substance into the fleshy fibres.

And as destroying or tying a nerve immediately stops the action of the muscle, which is solely supplied with filaments from that nerve, it appears natural to infer, that the additional substance flows through the nerve into the organism of the muscle.

And that this additional substance is no other than the liquid of the encephalon, the nervous fluid or animal spirits; the existence of which we endeavoured to prove in the preceding lecture.

LECT.

XII. The whole argument hangs very well together. It is made highly probable, almost, if not altogether to a demonstration, that there is a nervous fluid supplied by the encephalon, constantly flowing through the nervous tubuli. All muscles are plentifully supplied with nerves, which are distributed by minute ramifications through their whole substance, till they are past tracing. A muscle, while it is acting, swells, and grows harder in it's fleshy fibres, and therefore probably receives an addition to it's substance. The nerve, that solely supplies that muscle, being tied or destroyed, it's action is immediately stopt; whereas, if the artery, that solely furnishes it with blood vessels, is compressed or cut, the action of the muscle continues for hours after. This is a fair sorites, as logicians speak, the natural conclusion of which appears to be, that an influx of the nervous juice or animal spirits is the immediate cause of the swelling and hardness in the belly of the muscle; by which it is shortened, and it's ends, if they are moveable, brought towards one another.

There have been experiments made, that mightily illustrate and confirm this doctrine. We shall first mention that celebrated one contrived, as it is believed, by BELLINI, and give it you in the words of professor MONRO, who himself repeated it with success. " After opening, says he, the thorax of  
 " a living dog, catch hold of, and press one of  
 " both the phrenic nerves with the fingers, the  
 " diaphragm ceases immediately to contract. Then  
 " let go the hold of the nerves, and the muscle acts  
 " again. Pinch a second time the nerve or nerves,  
 " some way above the diaphragm, this muscle again  
 " ceases to act. Keep firm the hold of the  
 " nerve, and with the fingers of the other hand  
 " strip or milch it down from the gripping fingers  
 " towards the diaphragm, and the muscle is made  
 " to contract; and for three or four such strippings,  
 " or

" or milchings, it's action follows, or obeys the L E C T.  
 " motion of the fingers, which strip it down; then XII.  
 " it becomes disobedient, and will contract no  
 " more, milch as you will, unless the fingers grip-  
 " ping, or pinching the nerve, let go their hold,  
 " or are removed higher up upon the nerve, when  
 " the muscle may again be made to contract by  
 " stripping the nerve down towards it. This ex-  
 " periment, continues he, I have made with the  
 " success here mentioned. Let any one try, if he  
 " can imagine any other reasonable account of  
 " these appearances, than that the gripping fingers  
 " stopt the course of a fluid in the nerve: that  
 " what of this fluid was thus made to stagnate in  
 " the part of the nerve, between the gripping  
 " fingers and the diaphragm, was forced down into  
 " that muscle by the pressure of the fingers, which  
 " stripped the nerve down; and whenever this stag-  
 " nating fluid was pressed all away by several repe-  
 " titions of stripping the nerve, the muscle being  
 " supplied with no more fluid, contracted no more,  
 " till upon removing the fingers, which had hold  
 " of the nerve, a new supply of liquor was brought  
 " from the brain, or from the part of the nerve  
 " that had not yet been gripped or milched: and  
 " whenever this liquor could make it's way down  
 " to the muscle, or was forced down to it, the  
 " muscle immediately began to renew it's contrac-  
 " tile motions." So far this celebrated professor.

An experiment of Dr. STEWART's, mentioned  
 in his Latin Dissertation on Muscular Motion,  
 makes for the same purpose. He hung a live frog,  
 tied by the two fore legs, upon two pins, at a mo-  
 derate distance from one another, and in that posi-  
 tion he clipt off it's head with sharp scizzars; then  
 he gently put a smooth surgeon's probe into the hole  
 of the first vertebra of the neck, through which  
 the spinal marrow passes, easily touching the spinal  
 marrow; upon which the inferior extremities, which



LECT. before hung down lank and extended, were all in an instant bent upwards with a convulsive motion.

XII. And by, in like manner, pushing the probe into the hole of the os occipitis in the severed head, the muscles of the eyes and mouth became convulsed in a moment.

All this he found would succeed several times in the same frog, providing that an interval of some seconds was made between the trials; for when they were repeated too thick upon one another, the contractions became weaker, and less conspicuous.

You will observe with me, that in both these experiments there is no cause applied, that hath the least tendency either to excite elastic tremor, or to create spasm by acrimony. In that of BELLINI, there is only the finger applied to compress, and to milch down the nerve. In STEWART'S experiment, a smooth blunt probe is used. These cannot be thought to produce any effect different from common mechanical impulse, urging on the fluid contained in the nervous tubuli into the organism of the muscle.

Let us then assume as proved, that the accession of matter, by which a muscle, when acting, swells and becomes harder in it's fleshy part, is furnished by animal spirits flowing through it's nerves; the next enquiry is, after what manner this influx produces the swelling, hardness, and shortening of the muscular fibres.

As neither the naked eye, nor the best microscopes can discover the ultimate structure of a muscular fibre, we are obliged to use our reason in this abstruse matter in the best manner we can.

All authors, who maintain the reality of a nervous fluid, agree here in one thing; to wit, that the smallest fleshy fibres are hollow and distensible; and that the nervous tubuli open and pour their liquids into them; and by stretching out their middle

middle parts, shorten their lengths, and so occasion their contraction. LECT. XII.

But they differ as to the figure of their cavity. Many have imagined them to be chains of little vesicles communicating with one another. But as, upon an attentive consideration of that hypothesis, it was found that by such a contrivance there must be an unnecessary profusion of nervous fluid, it is now generally abandoned, and the cylindrical shape is come into it's place, it being demonstrable, that a cylindrical distensible tube is capable of being shortened with a given force, ~~with~~ <sup>+ by</sup> a less quantity of influent liquid, than a tube of any other figure. Nature brings about every thing in the simplest and most frugal manner, that it can be rightly done in.

TABOR, in his *Exercitationes Medicæ* printed at London in the year 1724, deserves to be read on this particular subject.

And this seems to be the simplest and most natural account of voluntary muscular motion; in which nothing is assumed, but what feasible reasons are assigned for. The will determines a flux of animal spirits through nerves, in which they are always present in sufficient quantity, into the cylindrical cavities of fleshy muscular fibres, thereby increasing their diameters, and shortening their axes with a certain degree of force, according to the strength of the muscle.

But, as the muscles that perform voluntary motion can at our will as readily cease acting, as they are excited into action, a difficulty naturally occurs to be solved, how are they so quickly restored to their natural state of relaxation; what becomes of the fluid, that had inflated them, upon their restitution? The best answer I can give, agreeably to the theory already delivered, is, that the elasticity of the fibres of the muscle, which were distended during it's action, after the will ceases to determine any more spirits into it's nerves, will instantly repel

LECT. them towards the source from which they came;  
 XII. to wit, towards their origin in the medulla of the  
 encephalon. And thus the muscle will chiefly be  
 restored to it's former relaxed inactive condition.  
 No doubt the propulsion of blood through the  
 small arteries, spread through the substance of the  
 muscle, which during the swelling of the fleshy  
 fibres were compressed, contribute something there-  
 to; and also the action of the antagonist muscles.

HALLER, in his notes on BOERHAAVE's Prelec-  
 tions, dislikes this solution. His words are *an  
 redit ad cerebrum? sed resistunt immensa vi novi qui  
 succedunt spiritus*. But why is the force of the  
 spirits immense, when they are not urged on by  
 the will? The motion of the spirits, when not  
 thereby influenced, must be very gentle, as they  
 can be but very faintly propelled by the heart and  
 arteries. And therefore I can see no inconvenience,  
 in supposing their being repelled to the brain in the  
 manner I have mentioned. Though the number  
 of nervous tubuli, even in a small nerve, is very  
 great; yet as their cavities are minute beyond ima-  
 gination, the sum total of the repelled fluid must  
 be extremely small, so as to create no sensible shock  
 on the encephalon. And room needs not be want-  
 ing for it, as both the nervous fluid itself, and the  
 encephalon, are in some degree compressible. It  
 were absurd to maintain, that it is accumulated in  
 any blind avenues. And if it were supposed to  
 make it's escape through the mechanism of the  
 muscle, the suitable inflation of the fleshy fibres  
 could not, I think, be effected.

There is another question of no less importance,  
 concerning these matters, that must be answered  
 here. As nerves are soft delicate tubes, and par-  
 ticularly so, when distributed through the substance  
 of a muscle, where having parted with their hardest  
 covers, they become as it were pulpy and medul-  
 lary, how can a fluid be made to move through  
 them



them with force enough into a muscle, to enable it LECT.  
to overcome great resistances, and move great XII.  
weights without injuring the tender and pulpy ~  
nerve?

MARIOTTE's celebrated experiment, which is mentioned by most writers on hydrostatics after him, will clear up this difficulty. Fill a strong tight cask with water, and set it on it's bottom: at an hole in it's head fix a long glass tube, as thin and as small as can be made, suppose twelve or fifteen feet long, perpendicular to the horizon, and cement it fast: put great weights upon the head of the cask, so as to bear down the center of the head, and make it appear concave without. This being done, pour water into the tube, and fill it to the top. If the tube is high enough, the small quantity of water contained in it, perhaps three or four ounces, will raise the great weights upon the head of the cask, and bring the external surface of the head from concave to plain; and all the while the tube shall be no more strained, than if there were no weights at all laid upon the cask, or if it's lower end were stopt altogether, and no wise communicating with the water in the cask.

If you should say, that the nerves that supply a muscle are neither so long as the tube we mentioned must be, nor placed perpendicular to the horizon, I answer, that impulse and velocity, in the motion of the nervous fluid, supply the place of length and altitude. A child, by blowing through a tobacco-pipe into an half inflated bladder, can easily raise great weights laid upon it.

The fleshy fibres then of a muscle may be compared to MARIOTTE's cask, and the nerves that actuate it to the slender tube; and thus it appears, how a very great force may be exerted by a muscle, without the least injury to it's nerves.

If our theory holds good, it will, I think, follow as a natural consequence, that the nerves, employed

*Thigh*

LEO T. ployed to influence motion, are a distinct class from

XII. those that excite sensation. When we stop the action, however violent and forcible, of any muscle, or set of muscles, we have no sensation in the particular place of that muscle or muscles. But in the restitution of a muscle, the nervous fluid is sent back to it's source, as well as in the nerves appointed for sensation, when their objects affect them. An additional argument may be drawn from the symptoms of palsy. A paralytic limb is sometimes deprived both of sense and motion, and sometimes only of the one of them, the other remaining. It would therefore appear, that the motory nerves, which are subservient to the will in influencing functions, with respect to which the mind is active, are distinct from those, which excite sensation, in receiving which the mind is passive, not only in their functions, but in their origin, progress, and termination.

Muscles have their antagonists, there being scarce any motion performed in the animal body by muscles, without a kind of motion directly opposite to it, which in it's turn can be effected by other muscles. Thus our limbs are bended and extended by opposite muscles; some parts are raised, and pulled down, &c. And we can *ad libitum* keep a kind of æquilibrium between opposite motions; so that the part acted upon by opposite muscles shall appear relaxed, and they seem not to act at all. But all the while, they really act in some measure; the nervous fluid, propelled on by the circulation, hath the effect to keep some kind of a *nifus* in every muscle; so that they are all of them, in some degree, in a violent state. This is proved by the phenomena of wounds; if the muscles, which bend the fingers for example, are cut through, the fingers remain extended, and *vice versa*. A wry neck is cured or mended by destroying a muscle that pulls it to one side, &c.

The

The mind, likewise, can keep a part firm in one position, by commanding a strong influx of spirits into all the muscles, which conspire to maintain that posture; and this state of a part or limb is called tonic. LECT. XII.

Before we conclude this intricate subject, we must again mention what we treated of before, when we were considering the action of the heart; to wit, the contraction of a muscle produced by irritation.

Lay bare in a living animal a muscle, and either prick it's fleshy part with a sharp pointed instrument, or touch it with an acrid liquor; suppose oil of vitriol, or apply remarkable heat to it; and the muscle will be immediately thrown into spasmodic contractions. This irritability of a muscle, as it is now called, continues after the nerve, which solely supplies it, is tied or destroyed; and even appears in some measure in muscles entirely severed from the body, if the experiment is made while they continue warm and moist.

Professor HALLER tied fast the crural nerve of a dog, immediately the voluntary motion of all the muscles of the limb was destroyed. Fifteen days after, the ligature being continued on, and the muscle remaining paralytic, irritation did not cease to manifest it's effects. Pricking, and the application of oil of vitriol, made the muscles of the leg nimbly contract.

So that this irritability of muscles does not depend upon a communication between them and the encephalon, by the intervention of nerves, as voluntary muscular motion evidently does.

And it seems to be a vis insita in a muscle, to rid itself of whatever has a tendency to violate it's fibres, which it retains as long as a certain degree of the heat and moisture, that are inseparable from life, remains.

But though it appears to have a different origin from the voluntary contraction, which requires sound-



LECT. nefs of nerves; yet it is not a contrary power, but  
 XII. a vis conspirans, the effect of both being contraction. The one seems to eke out, and as it were round, and complete the other. That from irritability is exerted most eminently, and in a manner the most important to animal life, in the heart.

We must likewise distinguish the natural contraction of a muscle, produced by mere elasticity, from that, which is owing to an influx of the nervous fluid. When a muscle in a living animal is cut through, it's fibres shorten, and are drawn towards their origin, or insertion. But this is but a weak contraction, equal to but a few ounces in the strongest muscles, which in a sound state can move many pounds. And yet some anatomists have confounded these two powers.

For the theory of muscular motion, besides the authors already mentioned, the inaugural Thesis of Dr. WINTER, now professor at Leiden, and the learned and accurate KAW, in his book *De impetum faciente Hippocratis*, in the chapter on muscular motion, deserves to be carefully read.

And professor HALLER's treatise on sensibility and irritability, originally published in the Transactions of the Royal Society of Gottingen, treats amply of these two subjects, and seems to open new lights in practice. Professor WHYTT hath wrote against some of his tenets. The controversy is important; and should be carefully read and considered by every student of physiology and medicine.

For the description of the particular muscles, and their actions, both single and complex, anatomists must be consulted; the chief of which are COWPER, DOUGLASS, WINSLOW, and ALBINUS.

BORELLUS hath given the best account of these complex animal motions, which are produced by the joint and successive actions of many muscles, as standing, walking, flying, swimming, &c.

## LECTURE XIII.

*Of some diseases of the brain, nerves and muscles.*

IN the last three lectures we treated of the functions of the brain and nerves, and of muscular motion; and delivered what to us appeared most probable, and least liable to error, concerning those copious and intricate subjects. We supported our doctrine with some of the plainest and most solid arguments we could find in the best authors, and urged them as fully as the plan of this compendious course could well permit; pointing out at the same time the fountains, from which farther satisfaction, with respect to these matters, may be drawn.

LECT.  
XIII.

The substance of our doctrine may be reduced to the following positions.

That the brain, taken in a large sense, or the encephalon, setting aside it's membranes and vessels, is composed of two different and distinct substances; to wit, cortical and medullary.

X large

That the former of these is the secretory or glandular part, by which a fluid, called animal spirits, the finest, thinnest, and most moveable of all in the animal body, is secreted or separated from the arterial blood, brought to it from the heart.

That the latter, to wit, the medullary part, is composed of the excretory ducts of the former, through which this fine fluid moves; and is conveyed to different parts of the body, to influence different functions.

That nerves are the medullary tubes continued, and distributed into distinct cords or bundles, containing and transmitting the same subtile fluid.

That by the various motions of this fluid, through the manifold intricate structure of the encephalon, the various operations and passions of our minds are influenced, in this our animal mortal state.

That

LECT. That by the reflux of this fluid through nerves,  
 XIII. towards their origin within the cranium, sensation  
 is produced.

That voluntary muscular motion is performed by the influx of this fluid from it's origin, through nerves, into the organism of muscles, urged on by the determination of the will.

And lastly, that muscles exercise a natural involuntary contractile motion, when irritated, which motion is independent on the encephalon, and the continuity of the nerves that belong to it. This property of muscles is called irritability.

These are the principal conclusions we endeavoured to prove in the three last discourses.

We shall, agreeably to our plan, while the doctrine is fresh in your minds, briefly touch on some of the principal and most frequent distempers of those parts, whose functions we have been explaining. And first, let us take into consideration that common complaint, pain in the head, or head-ach.

The most frequent, least dangerous, and most easy to be cured kind of head-ach, is caused by an over distention of the membranes of the encephalon, by the force or quantity of the blood moving through the vessels that come to it. But that distention must not exceed a certain degree, otherwise the cortical and medullary part would be compressed, and not only no pain be produced, but all sensation taken away, and apoplexy ensue. Tying the neck-cloth somewhat too tight will cause head-ach: but if violently urged, it will strangle, by totally stopping the return of the blood from the head, by the jugular veins.

This distention of the membranes, may be occasioned by whatever either increases the circulation in general, as fevers, in which head-ach is a symptom seldom wanting, hard drinking, heat of weather, violent exercise, &c. or by such causes as determine



terminate an over proportion of blood to the head: LECT. XIII.  
 as wind in the alimentary passage, and costiveness, which, by compressing the aorta and inferior vena cava, and their branches, confine the channel of the blood in the abdomen; whereby more thereof is derived upwards than should be. Cold bathing produces a like effect, by suddenly bracing the fibres and vessels in the trunk and surface, and so sending an over-proportion of fluids into the vessels of the encephalon; which vessels cannot be so much braced by the cold water as the rest, upon the account of the interposition of the solid cranium. Too tight a ligature about the neck, likewise ~~irritates~~ <sup>creates</sup> head-ach, as we have said, by retarding the reflux of the blood from the head, by the veins: while the arteries, lying more out of the reach of compression, and having their fluids moved through them with a more rapid force, continue to send up blood into the head, pretty nigh as freely as they would do, if there was no compression of the jugulars.

The indications of cure in this common kind of head-ach, if it is violent and obstinate enough to require forcible remedies, is, besides depletion of the vessels, if necessary, keeping the body open, and directing a cool diet, to draw from the head by blisters, issues, bathing of the feet and under parts in warm water, shaving the head, which creates a freer perspiration there; and particularly, to have a due regard to the precise cause, as by exhibiting carminatives, if the pain is occasioned by flatus, &c.

Besides these common causes we have assigned, there are not a few other which produce more dangerous and less manageable kinds of head-ach, as acrid ichor eroding the membranes in the lues venerea; ichorous abscesses affecting the medullary part of the encephalon, for it's cortical part seems to

LECT. to be void of pain; worms within the head, &c. for  
XIII. which turn over writers of medical observations.

Apoplexy, the most dreadful and dangerous of all the diseases of the head, is a deprivation of all sense, thought, and manifest motion, voluntary or involuntary, except that of the circulation and respiration, which not only remain entire, but seem often rather increased than diminished in this distemper, the pulse being fuller, and the breathing deeper and larger than in health. It is in every respect like unto a profound sleep, and not seldom accompanied with snoring; by which signs, and by the heat of the body, and the natural colour of the face continuing, and even appearing higher than usual, it is distinguished from a fainting fit, in which the pulse sinks, respiration seems quite suspended, the body grows cold, and the face becomes pale.

The immediate cause of apoplexy, is a total obstruction in the origin of these nerves, which influence sense or perception of every kind, and muscular motion, whether voluntary or involuntary, excepting that the causes of the action of the heart, and respiration continue unimpaired.

When we discoursed of the action of the heart, we shewed that one chief and indispensable cause of its contraction, (both in the auricles and ventricles) is irritation by the venous blood flowing into its cavities; and therefore, it is not to be wondered at, that the motion of the heart should continue after the nerves, which influence sensation and the action of other muscles, cease to exercise their functions. Of all the muscular parts of the body, the heart is the most irritable, as appears by its being susceptible of spasmodic motions when irritated, even after it is severed from the body. And as respiration is exercised in a sound state in sleep, as well as watching, we see it may subsist, after sense and voluntary motion are taken away.

The

+ and the  
peristaltic  
motion of  
the Intestines

The most frequent immediate causes that produce apoplexy, are either extravasation of blood from ruptured vessels within the cranium, or an accumulation of lymph, or serum, within the ventricles of the brain. I am convinced, that out of an hundred apoplexies that happen, ninety nine are brought on by either one or other of these two causes: and therefore, the indications of cure are chiefly to be levelled against them, this being a disease in which the true ætiology is so hard to come at; especially when we have had no opportunities of knowing any thing very particular, with respect to the case before us, which may not seldom happen. These indications are to bring about a reabsorption of the effused fluids, which is most effectually done by plentiful blood-letting, hydragogue purges, diuretics, and strong blistering.

In an English treatise, published in 1748\*, I have recommended trepanning in this distemper, after every other means prove ineffectual. This remedy was used by ARETÆUS in epilepsy, with success; and there appear strong reasons for extending it to apoplexy, which see in the treatise referred to.

Paralysis, or palsy, though its effects appear in the trunk and extremities, is yet often a disease of the head; and ushered in with a stroke of apoplexy. It is a deprivation of voluntary motion in a part, most commonly in a whole side; and then is called hemiplegia; sometimes, though very rarely, both sides are affected, and then it is termed paraplegia. Palsy, when it seizes either a whole side, or both sides, is a partial apoplexy; to wit, such a state of the origin of the nerves, that actuate the muscles of the affected part, as hinders a flux of spirits into them. Sometimes sense is also

\* A proposal for the improvement of medicine.



LECT. taken away, and sometimes it remains, but generally, it is considerably impaired and benumbed.

XIII.

Palfies affecting a particular limb, while the head and other parts are free, have their seats in the medulla spinalis.

The indications of cure in this distemper, after due evacuation and revulsion, are to open obstructions of the nerves, at their origin; and, at the same time, to apply warm penetrating things, in some measure stimulating, to the medulla spinalis, and the affected limbs.

Safe mercurials, as æthiops mineral, and native cinnabar, which is a mercurial ore; or, which is preferable, cinnabar of antimony, volatile salts, cephalic, warm and antiscorbutic vegetables; as rosemary, lavender, arum, mustard, horse-radish, sulphureous mineral waters, &c. differently exhibited or prepared, are most used in practice.

Epilepsy, or the falling sickness, is a distemper compounded of imperfect apoplexy, as in apoplexy there are no motions but those of the heart and respiration, and various convulsive motions, recurring by fits. In a paroxysm, the patient falls down, and hath no sensation while it lasts, and remembers nothing that happened during it: and therefore, a temporary imperfect apoplexy, is here a part of the disease.

The indications of cure are various, according to the various causes that produce it; for which we must refer you to practical authors.

Cramps, or spasms, are involuntary painful contractions of some particular muscles, while the sensorium commune remains clear and free; by which last mark, they are distinguished from those convulsions that appear in epilepsy.

As this disorder, though frequent, is, we apprehend, far from being in general rightly understood, we shall here consider it somewhat more particularly than we have the former.

Cramps

Cramps affect muscles in different parts of the body; as those under the chin; in the sides; those of the fingers and toes; but, most frequently of all, those in the calf of the leg. They are commonly imputed to some particular fault in the blood, or nervous juice; and, therefore, the chief stress is laid upon internal medicines for a cure. But the true origin of the disorder is more mechanical and simple. A cramp is such a state or position, however brought on, of some muscle, or sets of muscles, as destroys the natural equilibrium between them, and their antagonists; upon which these muscles, that are thus become over-powerful, are violently acted upon by the influx of nervous juice, which is always at hand, the nerves being full. Thus if we reach down, and towards one side too far, to take up any thing, a cramp will be caused in the muscles of that side of the trunk, towards which we reach, as I have often felt. The reason is, the muscles on the opposite side, that antagonise those that are bending the trunk towards one side, are so much stretched, that they become, as it were, paralytic, and lose their power. Their being distracted in length to such a violent degree, counteracts the influx of the nervous fluid into their fibres, at the determination of the will; while the muscles in action, the counterpoise being removed, contract with redoubled force, and this contraction being unusual and violent, creates pain.

But let us more closely consider the cramp of the leg, which is both the most frequent and the most troublesome of any, as it creates bad nights, and exposes the sufferers to catch cold, by being obliged to start out of bed.

It most generally affects people in the decline of life, when their thighs and legs growing less full and plump, the skin that embraces the muscles becomes looser and less tight, and it's texture less springy and elastic. And hysterical and hypochondriacal

LECT. diacal persons, who are liable to uneasy dreams,  
 XIII. and therefore tumble and toss in their sleep. And  
 more especially, when both these causes concur, the  
 disease becomes more frequent, obstinate, and violent.

From this account it appears, that the cramp in the leg is occasioned by the muscles being less tightly embraced by the skin, and membrana adiposa, and therefore less firmly kept in their due places than they should be. Hence it will happen, by tumbling in bed while asleep, when the will does not act in preserving an equal influx of nervous fluid into the different sets of muscles that move the leg, and balance one another, the gasterocnemii muscles, being the strongest, will sometimes act with more advantage than they should do, by some of the other muscles that antagonise them, being disadvantageously pressed upon, or jostled laterally somewhat out of their due position or direction. Those that dream and toss most, when asleep, are the most liable to this troublesome contraction.

Hence, likewise, cramps in the leg seldom or never happen in the day time, when one is awake; because the will then superintends the action of these muscles, and preserves a balance amongst them; and because they have not the same chance of being unequally pressed upon, or jostled out of their positions.

In a fit of the cramp, nature prompts us to start out of bed; to stand straight up, to stamp upon the floor with the affected limb, and rub the calf of the leg downwards; by which means the foot is bent, and the gasterocnemii muscles pulled down and relaxed, and the due position of the other muscles restored.

To prevent frequent returns of this troublesome complaint, besides avoiding such suppers as create uneasy dreams, and unsound sleep, the means I should most trust to, is sleeping with a tight laced stocking.



stocking, coming up above the knee. The radical cure is, restoring and confirming the general health, and plumping the habit.

## LECTURE XIV.

*Of hunger and thirst: aliments and strong drinks: mastication: deglutition.*

WE have already gone through those functions, LECT. XIV. which most immediately constitute life; which being discontinued but for a few moments, it would quickly be at an end (except in the case of a fainting fit, which may be considered as a temporary death); to wit, the action of the heart, and the motion of the blood and juices, influenced by that action; respiration, without which, in the born animal, the motion of the blood cannot be carried on; and the functions of the brain and nerves; and muscular motion; which are indispensibly requisite to maintain both the action of the heart, and that of the organs of respiration.

The next set of functions we shall consider, are those by which life is kept in repair, and rendered durable, and fit to hold out, barring accidents, the natural time to which it is limited. - This is a large class, comprehending all that are concerned in the desire or craving, in the assumption, the concoction of aliments, and their conversion into chyle, of which blood is made; and the distribution of nourishment over the whole body: and, which is consequential therefrom, the excretion or expulsion of what is superfluous.

Our bodies are in a perpetual flux. The most fluid and volatile parts of our juices, are constantly flying off by insensible perspiration. A great deal of water goes off daily by urine. There is a constant abrasion in the inside of the vessels, by the propulsion of fluids through them. And our juices, by the heat of our bodies, and perpetual agitation,

LECT. through the incessant action of the heart, even in  
 XIV. the most sedentary life, become, of course, more  
 and more inclined to alkaline, or putrid acrimony.

Therefore, a supply both of food and drink, from time to time, is indispensibly requisite for the support of life; the former, to furnish matter for the reparation of our solids, and to constitute the peculiar nature of the blood and juices, to be separated from it: the latter, as a vehicle or menstruum, to dilute and dissolve the food, in order to it's concoction and distribution, and to preserve a due fluidity and mildness in the different juices.

Now, by the wisdom and goodness of the supreme Author of nature, our bodies are so framed, that when they stand in need of a fresh supply of aliment, whether liquid or solid, we are prompted by an invincible desire, or appetite, to procure it, and take it in. If we were left to reason alone in this point, the species would soon be destroyed. The appetite, or craving for food, we call hunger, that for drink, thirst.

+ *partly*  
 x *either*  
 x *or*  
 The sense of hunger seems to be, ~~in some measure~~, excited by the coats of the stomach rubbing upon one another, ~~partly~~ by it's own vermicular motion, ~~and partly~~ by the impulse of the diaphragm, and muscles of the abdomen in respiration. It is, likewise, brought on by the sharpness of the saliva, which keeps constantly flowing down into our stomachs; and that of the natural juices, furnished by the coats of the stomach itself, especially the innermost, called the villous. As there hath been no fresh chyle, or, at least, not enough, for some time poured into the blood, otherwise the animal would not be hungry, the juices, as we have said, must become sharper, by repeated circulations, especially those we have mentioned, as they are exposed to the air, which promotes their spontaneous changes. Some remains of aliments, left sticking betwixt the rugæ of the stomach, and there growing

growing sharper, may likewise contribute to the same effect. When the mouth, tongue, and throat, the inside of the stomach and œsophagus, become dry, either through a general deficiency of aqueous particles in the blood, to render the secretions fluid enough, or by heat acting upon these surfaces, and drying them, by exhaling their humidity; and especially if both these causes conspire, thirst is created; a sensation, when intense, yet more intolerable than hunger.

Animals that are starved, in reality rot alive; their breath stinks; they suffer great pains at the stomach, from the acrimony of the saliva and gastric juices; and by degrees, a putrid fever comes on, which carries them off raving mad, the alcalescent sharpness of the blood and juices destroying the soft texture of the brain and nerves. Healthy persons have held out a week, and even a day or two longer, without either food or drink. But with water alone, (without any food) people may subsist a great while longer; as it hinders the putrid acrimony from increasing so fast, as it would otherwise do by diluting, and washing off the exalted salts, and rancid oils.

Our aliments, (under which term I comprehend both meats and drinks) to speak popularly, are all taken from animals, vegetables, and water. Some things, indeed, of the fossile kind, are used in food; as sea salt and salt-petre; but these serve only for seasoning, and are not, in their own natures, alimentary. I have said, speaking popularly, because, if we would speak with a philosophical accuracy, we should reckon air amongst the substances which nourish us, as, besides the air we draw in in breathing, we likewise swallow air in our foods and drinks; which being intimately dissolved in the alimentary mass, in the course of digestion, gets into the lacteals along with it, and becomes an ingredient in the composition of our chyle, blood and other juices,



LECT. juices, and, very probably, of our solids. But we  
 XIV. shall here treat only of animals and vegetables,  
 considered as alimentary, and suppose water to be  
 already known.

In the most early ages of the world, before the invention of the plough, and before mankind were furnished with arms and art to kill wild beasts, reason teacheth us, and the most ancient poets and historians agree in narrating, that man lived on such vegetable productions, as the earth brought forth without culture, and as they, by instinct and experience, found to be alimentary and safe, as well as agreeable to their palates. These were chiefly fruits, roots, farinaceous grains, and seeds. No doubt, the use of the milk of some quadrupeds, and the eggs of birds, is likewise very ancient.

In process of time, as mankind multiplied and spread over the earth, necessity compelled them to kill wild beasts, for their own safety: and, when hungry, they would naturally attempt to eat of their flesh, either raw or cooked; and if it proved agreeable to their taste, and at the same time wholesome, would continue to use it. Art grew with industry, and luxury with both. Hence the various ways of killing, catching, taming, and breeding animals, proceeded; and the numberless arts of cooking, would naturally be promoted and multiplied.

A proper preparation of our foods, contributes much to their wholesomeness and lightness of digestion: in general, the operation of fire, in some manner or other, as boiling, roasting, frying, &c. renders aliments both more agreeable to our palates, and more friendly to our natures, than they would otherwise be. Bread is improved, by being fermented previous to it's baking, as the particles of the dough are thereby more divided, and rendered more miscible with water, and, therefore, more easily conquerable by our digestive powers. Flesh and fish, by boiling in water, have their fibres rendered

dered more soft and tender, and therefore more easy LECT. to be broke by mastication, and fitter to part with XIV. their nutritive juices; while the juices themselves are at the same time made milder, and lay aside their disagreeable, as well as pernicious rawness. For raw foods in general, with very few exceptions, are unfit for the civilised part of the human species; and proper only for brutes and savages. Roasting and broiling of meat, is boiling it in it's own juice without dilution, and therefore gives it a higher flavour; and to a feverish stomach renders it more heating than boiled meat. Frying is boiling it in oil or butter, and makes it of more difficult digestion than the other two ways.

Foods are seasoned with salt, either common sea-salt, or that dug out of pits, which is precisely of the same nature; or with salt-petre: or they are seasoned with acids of different kinds, as vinegar, which is the best of all; the juices of acid fruits, as verjuice, juice of lemons, limes and oranges. Both acids and the salts we have mentioned preserve meats by resisting putrefaction, and temper their putrescent tendency in digestion. And, lastly, meats are seasoned with spices, of which nature yields great plenty, as well as variety. These procure a grateful flavour to aliments, and warm and invigorate the stomach.

As man is constituted, he appears to have been intended by nature to live upon both animal and vegetable food. He has teeth in both jaws, as all carnivorous animals have; and four of them canine, two in each jaw. His stomach is single and membranaceous; and his cæcum but small. And he is endowed with strength and agility, as well as skill and cunning, to kill or run down animals. At the same time he hath an appetite for vegetables, and that the stronger the better his health is, and the hotter the climate is he lives in. And a diet that is entirely animal or vegetable, to the human species,

*entirely*

LECT. species, is attended with great inconveniencies. The  
 XIV. latter produces both weakness of the body in general, and of the stomach in particular, and a frequent looseness. The former creates inhuman ferocity, as is credibly related of the savage cannibals; a disposition to fevers, alkaline scurvy in the highest degree, leprosy, and other cutaneous distempers. A sole animal diet, or what is nearly so, best agrees with people in extreme cold countries; as the Laplanders, and inhabitants of Greenland and Hudson's-bay, who live almost altogether on fish. The sole, or nearly sole vegetable diet does best in very hot countries, where a free use of flesh or fish would inflame and putrefy the juice, and render fevers both frequent and dangerous. A mixt diet best suits the temperate climates.

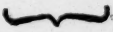
So that it would appear that nature decides the question, whether an animal or a vegetable diet is preferable, by shewing, that in general a mixture of both is best; and that the colder the country is, the more of the animal kind is required; the hotter, the more of the vegetable.

And the modern discoveries, concerning the nature of animals and vegetables, confirm and illustrate this conclusion. Every part of an animal, every animal juice, except milk alone, is alcalic, and tends to putrefaction. But the bulk of vegetables, used in our food, is acic; all the farinaceous grains, of which bread, that great support of life, is made; all, or most of the farinaceous roots in common use; all fruits, that are eatable, are of this nature; so that a mixture of alcalic and acic aliments is most proper to be made into a bland, neutral chyle, not inclining too much to either extreme. Besides, in animal food, there is a gelatinous juice ready prepared similar to the serum of our blood, and transmutable into it's nature, with less labour of concoction, than the juices of vegetables in common way require.

^

Hence,



Hence, to the human species, food from animals LECT.  
more quickly and more perfectly supplies and re- XIV.  
pairs strength and spirits than vegetables alone. 

But as the former would by itself be too alcalescent, too rank and heating, and incline too much to fevers, a mixture of the latter is requisite, and constitutes the most proper diet; especially in our climate, which is temperate, inclining to cold, where so strong bodily labour must be undergone by the bulk of it's inhabitants.

We shall say something concerning strong drinks. They are in general of two kinds, fermented liquors, or distilled. The fermented may be divided into two species; the one of which is made of the juice of ripe fruits fermented, as the juice of the grape, to which the name of wine is given by way of excellence: the other of the fermented decoction of farinaceous grains, which have been previously made into malt, and is commonly called malt-liquor. The other great class of strong drinks comprehends every kind of inebriating inflammable liquor, called spirit, which is produced out of fermented liquors, of whatsoever fort or denomination, by distilling them to a certain strength from the alembic. That from genuine wine is called brandy; those from other substances are distinguished by particular names, as arrack, rum, malt-spirit, &c.

The juice of grapes, which we shall take as the example of what produces fermented liquors of the first fort, before it is fermented is lusciously sweet, cooling, and loosening to the body; and in no degree inebriating. With a proper heat of climate it ferments of it's own accord, without any extraneous mixture: and if the fermentation is continued in a due degree, and for a proper length of time, becomes wine; widely differing from what it was before, harder and more poignant to the taste; exhilarating the spirits, heating, binding  
rather

LECT. rather than opening; and, if taken in a large quantity, inebriating: and lastly, which recommends it much to mankind, capable of being preserved a considerable time, and even improving by being kept.

The other kind of fermented liquors, to wit, that made of grain, requires, as we have said, a previous malting; which is effected, by first steeping the grain in water, then laying it on a floor in heaps, till it heat, and begin to sprout or germinate: after that it is dried and ground, and a decoction of it is made in water, called wort. Some make only a strong infusion in boiling water, without farther trouble.

Wort, before it is fermented, is lusciously sweet, cooling and opening, and not inebriating; agreeing in these qualities with the juice of the grape in it's natural state. Like it too, with a proper degree of heat, it would ferment without any addition; but imperfectly, and not so as to become good malt liquor. Yest therefore is added, in order to bring on a due fermentation according to art; and so it becomes ale: in Latin, *cerevisia*, *quasi vinum ex cerere*; resembling wine in it's principal effects; to wit, exhilarating, heating and inebriating; and yielding by distillation a spirit, still liker that drawn from wine in every respect, than the parent liquors are to one another.

By fermentation the vegetable oil in the fermentable materials is attenuated, so as to become mixible with water, and their salts exalted and volatilised; and intimately united with the attenuated oil, so as to rise together in distillation, producing an inflammable spirit. Another surprizing effect of fermentation, is to render the fermented liquor, under certain circumstances, and with proper management, capable of yielding that most useful production, vinegar. But for a most exquisite and full account of every thing relating to fermentation, and it's effects, consult

consult the great BOERHAAVE in the second part of LECT.  
his Chemistry. XIV.

Distilled liquors are clear and limpid; they are inflammable, being, as hath been said, the vegetable oil of the materials they are drawn from, first attenuated by fermentation, and afterwards by distillation, separated from the less volatile parts, and diluted in more or less phlegm or water rising with it, as the distillation is more or less protracted, and the spirit intended to be stronger or weaker. They exhilarate, and intoxicate like fermented liquors; but operate much more suddenly, and in much less quantity, if they are strong enough; that is, if they are what is called proof, or nearly so; and excess in them is attended with worse consequences. The stronger they are, the more powerfully they coagulate all animal juices, whether inwardly or outwardly applied; and crisp or corrugate the solids. And hence a great part of the bad effects, caused by a too free use of them, is owing to their obstructing the glandular system; besides spoiling the tone of the stomach and bowels, which they touch first; and affecting the head a thousand pernicious ways, of which the present age affords too many melancholy instances. In short, they are either a medicine or a poison, according as they are used; and hardly deserve to be ranked amongst aliments.

For a particular account of foods, SEBIZIUS de Alimentorum Facultatibus is much commended. But he wrote above an hundred years ago. All writers on the preservation of health treat of foods; as likewise writers of natural history, and on the materia medica. But methinks a new diætic system, adapted to our climate, times, and manners, if well executed, could scarce fail of being favourably received by the public.

Having treated of hunger and thirst, and of the nature of aliments, we proceed next to explain these

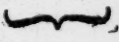


LECT. these actions of the animal body, by which they are  
 XIV. taken in or assumed, and concocted or digested, so  
 as to be mixed with our blood and juices, and at  
 length converted into the same nature with them.  
 The first of these in order are mastication or chewing,  
 and deglutition or swallowing.

The lower jaw is pulled down, and the mouth opened by the digastric muscle, assisted by all the other muscles which are fastened to that jaw, the os hyoides, and larynx, (for all these cohere together) whose fibres act in a direction below the articulation of the jaw. A great force is not required here, it being sufficient that the jaw can be readily, though not strongly, moved downwards.

But to pull it up, shut the mouth, and press the two rows of teeth against one another with a proper effect, a great force is required. Four strong muscles on each side, viz. the temporal on the temples; the masseter under the cheeks; the two pterygoidei backwards, the external and internal, but the former chiefly, serve for that purpose. All these muscles have their origins higher than the articulation of the lower jaw, and are inserted in the jaw itself. The united force of these muscles, when thoroughly exerted, is prodigious, as may appear from daily observation.

When a morsel is to be bit off, suppose a piece of bread, the jaw is first pulled down, and the mouth opened. Then it is forcibly pulled up by the muscles last mentioned, and the morsel being intercepted between the two rows of fore teeth, is cut off. These fore teeth, four in number in each jaw, cut like chissels, and thence are called incisores. Then the morsel is shoved by the tongue between the two rows of grinders, or dentes molares, on one side. The tongue is a muscular organ, furnished with muscular fibres running through it's substance in all directions; and therefore moveable all imaginable ways at our pleasure. Thus intercepted  
 by

by the alternate drawing down, and strongly pulling LECT. XIV.  
 up of the lower jaw, the morsel is broke and divided by the grinders. But farther, the jaw is   
 not only capable of a motion upwards and downwards, but likewise of a lateral motion, both from right to left, and from left to right, by means of a moveable cartilage, within the articulation, on each side, which is placed so loosely, as to admit of being shoved either way. This lateral motion is performed by the successive action of the same muscles on their respective sides, so that the morsel is not only bruised and divided, but likewise truly grinded.

By the action of these muscles in chewing, there is constantly saliva forced into the mouth. This is a watry, transparent, almost insipid liquor, not concrescible by heat, but evaporable; very slightly saline; neither acid nor alcalious; yielding, when analysed, a very small quantity of oil, fine earth, and lixivial salt. The saliva, besides what comes from the minute glands and inhaling vessels on the internal surface of the cheeks, and outer surface of the tongue, is supplied chiefly by the parotid gland. This gland (one on each side) lies near the ear, covering part of the masseter muscle, and sends from it a large excretory duct opening ~~into~~ the cheek. Contiguous to it is another salivary gland, called maxillaris, of the same structure and use, but much less, situated at the angle of the jaw; and from this a production of the same structure stretches forwards along with the jaw, under the membranes of the mouth and tongue. This production, though continued with the other, without any dissimilar substance betwixt, hath got a separate name, and is called sublingualis. From the maxillaris an excretory duct opens into the mouth, near the frænum of the tongue. From the sublingual part, short ducts, of different numbers in different subjects,

*+ within*

LECT. subjects, arise, and opening at the edge of the  
 XIV. tongue disembogue their liquids into the mouth.

These salivary glands are so placed, with respect to the muscles that act in mastication, that every muscular action compresses and evacuates some part of them, propelling saliva into the mouth. In opening the mouth, the digastric muscle presses upon the maxillary gland, and makes a small spurt; and the masseter muscle, swelling while it pulls up the jaw, squeezes the parotid gland.

The saliva is of a penetrating, detergent, saponaceous nature, and the more so, the longer one hath fasted. It is endowed with a wonderful power of promoting fermentation, when mixt with fermentable materials. Between meals we imperceptibly swallow it down into the stomach, so that what is not employed to moisten, and be intimately mixed with the food in chewing, is not lost, but saved to whet the appetite, and assist digestion. And therefore a frequent and habitual expuition is in general hurtful, as it blunts the appetite by preventing the sense of hunger; and by robbing concoction of one of it's principal instruments. ~~A large compilation, relating to the saliva, may be found in the Stenographia of Senarius.~~

When the morsel is sufficiently moistened, comminuted and ground, and as it were kneaded with saliva, and at the same time with air; for during the whole process of mastication, a mixture of air with what is chewed is unavoidable; it is then fit to be swallowed.

Before we enter into an account of deglutition or swallowing, which is one of the most complex, and most difficult to be explained of all the actions in the animal body, it will be proper to give you some idea of that cavity in which it is principally exercised; to wit, the fauces or throat.

It may be said to begin immediately behind the last dentes molares, opening there into the cavity  
 of



of the mouth. It likewise opens above and anteriorly into the passage through the nose. Its lower parts are terminated by the root of the tongue, next that by the larynx, and farther back by the pharynx, and entry into the œsophagus. Its walls behind are formed by some of the first vertebræ of the neck; and its uppermost parts or roof by the occipital and sphænodal bones. This ample and shapeless camera is divided, but not to the bottom, by the velum mobile, or, as it is sometimes called, the velum pendulum palati, which is a thick fleshy curtain, formed by the conjunction of the membranes that line the roof of the mouth, and the passage through the nose, extended backwards and downwards. It is fixed above and laterally to the ossa palati; but its inferior margin, which is arched, with the uvula in the middle of the arch, hangs loose and floating; and divides the cavity of the fauces some way down, but not to the bottom, as has been already said.

This velum or curtain is moveable either upwards and backwards, or downwards and forwards; for which purposes it is furnished with particular muscles, a description and figures of which see in the works of the incomparable ALBINUS. When it is drawn upwards and backwards, it stops the passage between the nostrils and fauces like a valve, hindering air or any thing else from passing that way. When it is pulled downwards and forwards, and at the same time the tongue is drawn upwards and forwards, and pressed against it, by its proper muscles, a firm barrier is formed, by which all communication is cut off betwixt the cavity of the fauces and mouth.

The larynx, which is the head of, and entry into the aspera arteria, lies immediately behind the root of the tongue, and closely adheres to it by membranes and vessels. Before the glottis or opening into the larynx stands the epiglottis, a flexible cartilage

LECT. tilage of an elliptical figure, which, when pressed  
 XIV. back, completely covers that opening, and hinders  
 any thing from resting on, or falling into it. The  
 larynx is furnished with muscles both to raise and  
 pull it down.

The pharynx is the entry into the œsophagus, lying behind the larynx, and constituting the chief part of the cavity of the fauces. It may be compared to a funnel with it's wide part uppermost, and it's narrow part implanted into, or rather continued with the œsophagus. It is, setting aside it's membranes, blood-vessels and mucous glands, chiefly a tissue or web of muscular fibres, of various origins, directions and terminations; by the action of which it is capable of being contracted or widened, raised or depressed, in whole or in part, as the occasions of deglutition may require; the unravelling of which hath very much exercised the heads and hands of the most dextrous and inquisitive anatomists. They have, for the sake of accuracy and precision, been obliged to bestow particular hard sounding names upon every distinct bundle; which are apt to puzzle and fright beginners, and render it difficult to be understood.

Let it be observed, that the whole cavity of the fauces, as well as that of the mouth, is kept constantly moist and lubricated, not only by saliva, but likewise by inhaling vessels, and mucous excretory ducts, (the most conspicuous of which are those from the tonsils,) opening in great plenty upon the surface of all the parts we have been describing.

These things being premised, we come to describe the action of deglutition itself. We suppose the morsel or bolus sufficiently chewed; that is sufficiently comminuted, moistened and mixed with saliva and air, and fit to be swallowed; in order to be so, it is first brought into the cavity of the fauces by the tongue, which takes it up like a scoop; and being

being pressed against the roof of the mouth, and urged L E C T  
XIV.  
backwards, carries it into the beginning of that ca-

vity, while it's return towards the mouth is by the same means effectually prevented. Next it is pushed into the pharynx, while at the same time it is hindered from falling, in the smallest quantity, into the aperture of the larynx, which would endanger suffocation, and from getting into the passage through the nose. The former is brought about by the tongue's continuing to be urged backwards, while at the same time the larynx is strongly raised, and the epiglottis pressed against the tongue; and instead of it's erect natural position forced backwards, and made to lie flat upon, and completely cover the passage into the larynx. The velum palati is at the same time pretty strongly drawn downwards and forwards, chiefly by the Thyreopalatini muscles, and carries down the morsel along with it, thereby hindering it from getting upwards into the passage through the nose. So that the same contrivance that propels the bolus into the pharynx, likewise secures it against making it's escape any other way. But while all this is going on, the pharynx is raised and opened to receive what is to be swallowed, by such of it's bands of muscular fibres as are fitted to these purposes: and that part of the cavity of the fauces, which is anterior to the pharynx, being in a manner annihilated by the larynx being raised, the root of the tongue urged backwards, and the velum palati pulled down, there remains no other way for the bolus to pass, but into the pharynx so raised and widened. When this is done, it is to be propelled out of the pharynx into the oesophagus. For which purpose the muscles, that before pulled the larynx upwards, must now cease acting, and those come in play, which draw it downwards and backwards; thereby pressing it against the pharynx, while at the same time these muscular ~~plans~~, which constrict the pharynx, exert themselves, beginning  
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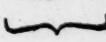
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planer



LECT. their contraction from it's uppermost parts, and  
 XIV. continuing it successively downwards: the velum  
 palati being still kept as a lid above it, and determining the descent of the bolus. And thus it is thrust into the œsophagus, through which it is sent into the stomach, partly indeed falling down by it's own gravity; but chiefly urged on by the action of the muscular fibres of the œsophagus itself.

But we must not omit taking notice, that, besides the epiglottis, there is another contrivance to secure the glottis against any thing falling into it in swallowing; to wit, particular small muscles, which acting together, shut it like a sphincter, by pulling the cartilages that form it close together. They are three, called aryarytenoidæ, one streight, and two oblique. These muscles, no doubt, act when their service is wanted during deglutition; and that seems chiefly to be when the larynx, that immediately before was pulled up, and the epiglottis strongly pressed against the tongue, is let down, in order to the evacuation of the pharynx. For at that time the epiglottis being permitted to raise itself somewhat from the passage into the larynx by it's elasticity, there would be greater chance for some part of the bolus getting into the rima glottidis, without such a contrivance to prevent it.

We have not mentioned all this while the uvula, as assisting in the action we have been describing; though BOERHAAVE, and his followers, lay considerable stress on it, contending that it serves to guard the rima glottidis. But, besides that the epiglottis is broad enough to cover completely the passage into the larynx, and that the most accurate anatomists find the uvula unfit for the office assigned to it, both as to position and structure, it is entirely wanting in brutes, whose deglutition is, no doubt, as operose and intricate as that of the human species, as they take their food with their heads down. I therefore incline to believe with HEISTER, that it's  
 use

use is for the more perfect modulation of the voice, L E C T. and perhaps likewise for the more complete stopping XIV. of the passage towards the nose, by eking out the  velum palati.

I shall close the account of this intricate action, by observing with the immortal \* HARVEY, that though it be so compounded, requiring so many different, and even opposite motions to complete it; yet the whole is done in the twinkling of an eye, and as it were at once. His passage is remarkable and curious, and you will be agreeably surprised to find therein almost a perfect account of deglutition near an hundred years before BOERHAAVE. It runs thus, "*In deglutitione, radieis linguae elevatione, & oris compressione, cibus vel potus in fauces deturbatur; larynx a musculis suis, & epiglottide clauditur; elevatur & aperitur summitas gulæ a musculis suis (haud aliter quam saccus ad implendum attollitur, & ad recipiendum dilatatur) & cibum vel potum transversis musculis deprimit, & longioribus attrahit: & tamen isti motus a diversis & contradistinctis organis facti, cum harmonia & ordine dum fiunt, unum efficere motum videntur, & actionem unam quam deglutitionem vocamus.*"

## LECTURE XV.

*Of angina or quincy. The action of the stomach. Some practical conclusions.*

HAVING in the last lecture explained masti- L E C T. cation and deglutition, we might now pro- XV. ceed to give an account of the action of the stomach  or ventricle, in which the aliments undergo the next considerable change, in order to be converted into chyle first, and afterwards into blood, and the juices to be separated or secreted from it. This change, which they undergo in the stomach, is

\* *De sanguinis circulatione.*

LECT. commonly called digestion by way of eminence,  
 XV. though, as we shall see afterwards, the intestines  
 have a much greater share in concoction and chyli-  
 fication than the stomach. But, before we enter  
 upon these subjects, we shall, agreeably to our plan  
 of shewing the connexion between physiology and  
 the rational practice of medicine, take into consid-  
 eration a very frequent, and not seldom, a very  
 dangerous disease, whose seat is in the parts we  
 have been last treating of; to wit, angina, in  
 English quincy, or sore throat.

It is the acute or inflammatory kind we shall  
 here consider. It may be defined an inflammation  
 of some part or parts, either within, or contiguous  
 to the throat, rendering deglutition painful, or im-  
 practicable; and when it is of the most dangerous  
 kind, likewise affecting respiration.

When only swallowing is impaired, the parts in-  
 flamed may be the tonsils, the velum palati and  
 uvula, the muscles of the pharynx, and those of  
 the larynx, which raise it, or pull it down in de-  
 glutition, but whose action is not concerned in mo-  
 derating the aperture of the glottis; while the  
 larynx itself, and the aspera arteria remain free.

But when respiration is pinched, besides other  
 parts, these muscles must be inflamed, (either in  
 their membranes, or their fibres, or both) which  
 are employed in opening and shutting the glottis;  
 and likewise probably the inner membrane of the  
 larynx, and those muscular fibres and their mem-  
 branes, that join the rings of the aspera arteria to-  
 gether. And sometimes these minute and remote  
 parts are affected without any redness or tumor ap-  
 pearing either within the fauces, or outwardly on  
 the throat. This kind of angina is the most dan-  
 gerous, and suddenly destructive, of all.

The practitioner in every kind of angina ought to  
 look carefully into the mouth and fauces, in order to  
 spy out where redness and tumor is, that by comparing  
 the



the appearance of the parts with the functions impaired, he may be enabled to form the better judgment with respect to the seat of the disease, the prognostic, and method of cure. LECT. XV.

If breathing is remarkably affected, there is an absolute necessity of applying all the most efficacious remedies with the greatest briskness and speed possible. These are plentiful and repeated bleeding; a large blister betwixt the scapulæ; fomentations and cataplasms outwardly; steams to be received into the throat, the best ingredient in which is vinegar; smart but cooling purges, or, if these cannot be got down, glysters of the same kind; bathing the feet and legs in warm water, and even semicupiums: but care is to be taken that the water be not made too hot, lest more harm should be done by raising the pulse, than service by revulsion and dilution. It should therefore but little exceed the warmth of new milk.

But even though respiration is not affected at first, if the symptoms are otherwise violent, remedies ought to be smartly and quickly applied to prevent suppuration. For when the inflamed part tends to suppuration, the tumor keeps increasing; and when pus is actually formed, the bulk may be so enlarged, as to endanger suffocation, though the respiratory organs are not primarily interested. Or the patient may be starved by a total privation of swallowing: so that suppuration should always be prevented, if possible.

If in the course of the distemper the patient runs a risk of being suffocated, surgeons have thought on a way of giving relief, and postponing fate, by opening the aspera arteria, an inch or two under the polum adami, or body of the larynx, cutting between two of it's rings, and putting a silver or lead canula into the aperture, so that the patient may breath through the canula, instead of breathing through the glottis. This operation, called bron-

LECT. chotomy, is perfectly safe, and easily performed; and  
 XV. no surgeon should hesitate at going about it, where  
 it is necessary. But prudence requires that he should  
 give warning before hand, that, in case the worst  
 falls out, the patient's death ought in justice to be  
 imputed to the disease, and not to the operation.

If the tumor comes to suppurate, and the surgeon  
 can reach it safely with his instrument, it should be  
 opened. The smallest quantity of matter let out  
 will often give unspeakable relief; and the rest, by  
 using emollient and gently deterging gargarisms  
 will follow. If it is out of reach, frequent syring-  
 ing warm emollient liquids into the throat, with the  
 like cataplasms outwardly applied, are the chief  
 means, within the power of art, to promote it's  
 breaking.

If the patient runs a risk of being starved, be-  
 sides nourishing glysters, a bath or semicupium of  
 warm milk or warm broth may, no doubt, be used  
 with success. This I wonder not to have found  
 directed in authors, considering the acknowledged  
 certainty of absorption through the pores of the  
 skin.

But let us return to the animal œconomy.

As we have before but just mentioned the œso-  
 phagus, we shall now give some description of it.  
 It begins at, or is continued with the pharynx, runs  
 down along the posterior part of the thorax, be-  
 hind the aspera arteria, and most commonly some-  
 what to it's left, passes through the diaphragm, and  
 a short way under, it opens into the stomach, into  
 which it conveys the aliments.

It is made up of several membranes or coats.  
 The external one is cellular; next to that is the  
 muscular coat, consisting of two pretty strong  
~~planes~~ <sup>planes</sup> of fibres, the exterior of which is nearly  
 longitudinal, the interior nearly circular. When  
 the former act, they shorten and widen the tube,  
 thus fitting it to receive the aliments: when the  
 latter

latter exert themselves, they render it narrower and longer, and propel the aliments onwards. This alternate action, begun at the origin of the canal, and continued downwards successively through it's different portions, one after another, determines the rout of the aliments into the stomach. LECT. XV.

It's innermost coat, called nervous, is tough and strong, fit to resist the hardness and roughness of what may be swallowed. It is lined with short villi standing up like velvet, somewhat in the manner of those in the stomach and intestines, of which we shall speak by and by. There are likewise numerous secretory ducts opening into it, which yield a mucous liquid, by which it is moistened and lubricated, in order to facilitate the passage of the aliments through it's cavity.

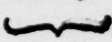
The stomach or ventricle is situated in the abdomen, immediately under the liver, which covers a great part of it above and laterally. It is placed transversely, in the main, from right to left, but somewhat obliquely, so that it's left orifice, which is continued to the oesophagus, lies more towards the vertebræ, and the right, called pylorus, which opens into the intestine duodenum, more anterior. In figure it resembles a bagpipe; it's thickest part being it's left extremity at the implantation of the oesophagus, from which it tapers to the pylorus. The cartilago ensiformis answers nearly to it's middle. The spleen lies contiguous to it's lower part on the left; and the pancreas behind it's bottom.

The structure of the stomach is in general the same with that of the oesophagus, of which it may be considered as a dilatation. It's most external membrane is a continuation of the peritonæum; it's next is cellular, in which it's great branches of blood vessels and nerves run; in it there are likewise conglobulate glands, and lymphatic vessels. Under this lies the muscular coat. The exterior layer is



LECT. is a continuation of the longitudinal fibres of the  
 XV. œsophagus, which open and disperse themselves  
 over the stomach; and as the stomach is by much the larger of the two, and of an irregular figure, they must of course be thinner, and less numerous in some places than in others. They run mostly along the length of the stomach, and terminate at the pylorus. They seem to shorten the stomach, though but in a feeble manner, and widen it's middle. The other stratum answering to the circular fibres of the œsophagus, is by much the stronger of the two. It's fibres run in a general way round the stomach at right angles with it's axis, though with considerable and intricate deviations. They seem, like the analogous stratum in the œsophagus, to lengthen the tube they encircle, and contract it's cavity. A remarkable plain of this same stratum runs from the left orifice to the right by the shortest way; to wit, along the upper and lesser curvature of the stomach; and appears to counteract it's other fibres, by drawing the two orifices towards each other. And it is observed, that at the entry of the œsophagus into the stomach, the circular fibres are remarkably thick and strong, which therefore may serve in some measure as a sphincter to it, and shut it's cavity there. But, upon the whole, the exact course of the muscular fibres of the stomach is so extremely difficult to be traced and described, that hardly any two anatomists, unless they copy from one another, agree in their account of them. It is sufficient here to conceive them to be so framed and distributed, as to enable the stomach to press upon it's contents every way, and gradually to expel them.

Next to, and immediately under, the muscular coat, is another cellular texture, more conspicuous than the exterior one, in which pretty large trunks of blood vessels and nerves run, after having penetrated through the muscular coat. Under it lies  
 that

that coat called nervous, which is a firm, tough, L E C T. white, and pretty thick membrane, constituting XV. the principal and most peculiar coat of the stomach. 

The sixth in number is another cellular web, much thinner, and more subtile than the two former, made up of shorter threads or laminæ. The innermost of all is the villous coat, so called because it hath villi, or a pile, like that of velvet, standing out from it. These villi are small membranous productions or sheaths, containing minute tubuli, both of the arterial and venous kind, opening into the cavity of the stomach. The arteries have been injected by RHUYSEN; the ceraceous matter passing into the stomach, but leaving the vermilion, by which it was tinged, behind it; so extremely fine and small they are. The arterial tubuli pour into the stomach a liquor much more subtile than blood, to be mixed with the aliments for the purposes of digestion. And when the stomach is empty, this liquor growing sharper, concurs with the saliva in exciting the sense of hunger, as hath been said; and it is probably from these, when dilated, that vomitings of blood proceed in women, whose menses are suppressed. The venous tubuli resorb liquids from the stomach. This innermost or villous coat being larger than the rest, forms wrinkles here and there, more or less conspicuous. But at the pylorus there is a remarkable one; where a duplicature of the coat formed by this wrinkle all round the pylorus, and projecting into the entry of the duodenum, serves, together with the circular fibres of the muscular coat, to contract, and almost shut that orifice, and let only the thinner parts of the alimentary mass be expelled out of the stomach into the intestine very gradually, and in small quantities at once. Over all the inside of the villous coat there open excretory ducts of mucous glands, seated in the second cellular membrane, which furnish a lubricating liquor, as in the œsophagus, serving to defend

LECT. defend the acutely sentient inside of the stomach  
 XV. from the acrimony, or otherwise hurtful qualities,  
 of what we may eat or drink. These openings are  
 more conspicuous in the stomach of pigs than in  
 the human.

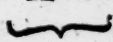
The stomach is plentifully furnished with blood vessels. It's arteries all come from the cæliac; and it's veins all empty themselves into the vena portarum. It is no less largely supplied with nerves, every branch of which arise from the par vagum.

In order to give you a distinct, and tolerably full idea of the action of the stomach, we shall, with BOERHAAVE, consider it first as a warm, moist, distensible vessel, receiving and retaining the meats and drinks that are thrown into it: secondly, as it is pierced with pipes and orifices, furnishing other fluids requisite for digestion, to be mixed for that purpose with the contained aliments: thirdly, as it is, in some measure, an hollow muscle acting upon it's contents; and, lastly, as it is by it's situation subjected to external pressure and agitation.

If it is considered in the first light, to wit, as a close, moist, warm, and distensible vessel, receiving and retaining for some time our meats and drinks; we may observe, that the mash thrown into it from the œsophagus, masticated or chewed, and intimately mixt, and, as it were, kneaded with saliva and air, and diluted with our drink, will, by mere standing in such a vessel and in so warm a place, be macerated and farther dissolved. The heat of the inside of the animal body, is considerably greater than that of the atmosphere, even under the equator. So that here is a warm infusion of solids mixt with fluids; the natural effect of which, were there no other cause concurring, is maceration and dissolution, and mixture or incorporation of the dissolved solids with the dissolving fluids. Besides, such ingesta as are disposed to ferment, will in that heat begin to ferment; and such as tend to putrefaction will



will begin to putrefy. Both these changes will be L E C T. promoted by the air, and saliva mixed with them. XV.

Air is absolutely necessary for fermentation; and,  to say the least, promotes putrefaction. Saliva, as has been hinted, wonderfully assists fermentation. This effect it produces, not as an acid or an acedent liquor, it being neither acid nor alkali, but rather tending towards alkali, as all animal fluids are, except milk. It must, therefore, operate here by it's saponaceous quality in opening the body of fermentable subjects, and carrying air in small bubbles, inviscated by it's ductile tenacity amidst their molecules; and by the same property it promotes putrefaction likewise. If there is a mixture of fermentable and putrescible contents, the fermentation of the one being opposite to the putrefaction of the other, a *tertium quid* will be formed, partaking of the nature of both. This intestine motion promotes the comminution and dissolution of the aliments, rendering them more intimately miscible with the diluting liquids. And as both fermentation and putrefaction generate elastic air, the contents of the stomach will be rarified: and hence the stomach swells in digestion; not indeed so, as to be troublesome to persons in health, if they are moderate, but often extremely uneasy to the valetudinary. Upon the whole, the effects of the aliments remaining some time in the stomach, considered merely as a close, moist, distensible vessel, situated in a warm place, will be maceration, dissolution, beginning putrefaction or fermentation, rarefaction, intimate mixture, and reduction, to nearly an homogeneous mass.

If we regard the stomach as a vessel receiving into it's cavity liquors, *ab extra*, besides the meats and drinks, to promote it's action, let it be observed, that we are constantly swallowing down saliva, as hath been said: that while the oesophagus constantly furnishes liquids, to moisten and lubricate

LECT. it's own internal surface, the overplus falls into the  
 XV. stomach: that the villi in the innermost coat yield  
 a fine elaborate juice, called *liquor gastricus*, to be  
 mixed with the mash: all these put together amount to a considerable quantity; of which, probably, the saliva constitutes by much the greater part. These liquors being already, by prior circulations and the energy of the viscera, converted into animal nature, must, by being mixt with the new ingested contents of the stomach, farther perfect them, rendering the whole mash more inclining to an alcalescent disposition, and less dissimilar to our blood and juices, than otherwise it would be: besides farther dilution, maceration, dissolution, and more intimate mixture.

The mucus, furnished by ducts opening into the innermost coat, serves to defend the stomach, by it's oily visciduity, against roughness, hardness, and acrimony in the ingesta. And if we consider what a vast variety of meats and drinks, of different tastes and properties, is freely used by the human species all over the globe, either through necessity, or through luxury and wantonness, it will appear amazing, that the stomach and intestines should be able to receive, digest and subdue them, with so much ease and safety as they do. This is owing, in a chief measure, to the immense quantity of mucus furnished by secretory contrivances, so plentifully dispersed all over the inner surface of the alimentary passage, *ab ore ad anum*; whereby their otherwise nervous and acutely sentient membranes, are secured and protected. But of this more, when we come to treat of the intestines.

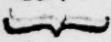
If we consider the stomach as an hollow muscle, being furnished with strata of fibres running in different directions, we shall find the most obvious effect of such a structure, will be closely to embrace it's contents, and retain them some time. And this I take to be the chief action of the muscular fibres

in such membranous stomachs, as the human is. LECT.  
XV.  
 But if we suppose the different strata to act successively, the longitudinal one way, and the circular another, there may be some obscure vermicular motion produced; which will contribute towards shaking and mixing the contents together, thus promoting the intestine motion in the mash; and the gradual expulsion of it's most fluid, and best concocted parts.

Lastly, if we consider the situation of the stomach, as subjected to external agitation and pressure, we shall find it acted upon, without ceasing, by more than one cause of this kind. And first, the aorta descendens, and other large arteries that lie contiguous to it, by their repeated pulses, must alternately compress it, and leave it at freedom. Though this may appear trivial at first view, yet if we reflect, that arteries are dilated and contracted (and the large ones with great force) between 4000 and 5000 times in one hour, we shall be forced to own, the sum total of their action upon the stomach, from one meal to the next, to be considerable. BOERHAAVE, in his Lectures, always pronounced it greater than that of the muscular fibres. But besides, in respiration the stomach is constantly agitated and prest upon. In inspiration, the diaphragm presses down the liver upon it; and in expiration, the abdominal muscles press it up against the liver. This reciprocal pressure is incessant; and if we reckon one act of respiration to four pulses, which is rather an under proportion, the whole will amount to above 24000 such pressures in 24 hours, even in a sedentary life. If we use exercise, the pulse and respiration become both quicker and stronger. And hence the good effect of exercise to promote digestion.

Though we have, for clearness sake, thrown the whole of the causes of digestion in the stomach, under four distinct heads, and treated of these heads  
 one



LECT. one after another, yet we must conceive them as  
 XV.  going on, at least in some measure, all at once, harmoniously conspiring towards the same end; to wit, the concoction of the aliments, and their expulsion, when concocted, through the pylorus. But with respect to the latter, let us observe farther, that the implantation of the œsophagus into the stomach is much higher than the pylorus; and the passage of the œsophagus between the fleshy fibres of the diaphragm, which may be considered in some measure as a sphincter of the stomach at it's left extremity, still higher than that: that the liver lying upon the left and widest extremity of the stomach, favours the propulsion of the contents of the stomach more towards the pylorus, than towards the other extremity; and lastly, that the valve or ruga at the pylorus, which we mentioned, rather straitens or confines, than altogether shuts that orifice, as it projects into the duodenum, and, as it were, leads that way. If these things are attentively considered, it will appear that the most fluid, and best concocted parts of the mass in the stomach, must naturally, though slowly, and in small quantity together, be propelled into the intestines.

From this account of the action of the stomach it is plain, that to confine it to any one cause or modus, is a very great error. ERASISTRATUS, we are informed by CELSUS in his valuable preface, ascribed digestion wholly to triture; PLISTONICUS to putrefaction; under which term probably he likewise comprehended fermentation, as the ancients had no precisely distinct ideas of these two changes, but generally confounded them together. HIPPOCRATES attributed it to heat: and ASCLEPIADES rejected all these causes, contending that the aliments are distributed all over the body, in the same state as when ingested. Now all these celebrated men were partly in the right. Their error lay in

attributing that effect to one cause only, which is LECT.  
produced by the concurrence of many. XV.

The celebrated PITCAIRN, not very long ago, endeavoured to revive the doctrine of ERASISTRATUS; but his system is now universally abandoned. Both stomach and intestines, by their joint action, cannot always break soft berries that are swallowed whole, such being often voided so by stool. Birds indeed, that live on grains, and having no teeth swallow them entire, are furnished with two stomachs; the one, called the crop, is thin and membranous; the other, termed the gizzard, is a very strong muscular machine, with a small cavity, lined with a thick callous membrane. In the former, the grains are moistened, macerated, and rendered soft: in the latter, they are truly ground; the birds swallowing small pebbles to promote the triture. This contrivance stands them instead of teeth. But the human species are furnished with teeth, and have no supplemental stomach, endowed with robust muscular fibres. Fishes, on the other hand, which, in general, are extremely voracious, and swallow their prey whole, are provided with thin and soft stomachs. And as they do not breathe through lungs, like land animals, and therefore, are without the reciprocal action of a diaphragm and abdominal muscles, to press upon, and agitate their stomachs, they seem to perform the whole of digestion by the sharpness of their bile, acting on the aliments as a menstruum; with little or no assistance even from heat; as the inside of their bodies is scarce any warmer than the element they swim in.

Many practical conclusions may be drawn from this account of digestion, which the nature and contractedness of our course will not permit us to enlarge on. We shall therefore, only touch upon a few of the most important.

LECT.

XV.

As the stomach is plentifully supplied with nerves, it is no wonder it should be liable to pain, and that often extremely acute and violent. Like other parts, it is subject to true inflammation; though by the beneficent provision of nature, that seldom happens, for all the unbounded freedoms people use with it. An inflammation of the stomach is to be treated like other local inflammations, proper regard being had to it's structure, situation, and functions.

Pains in the stomach, without inflammation, may be occasioned by flatulency distending it's coats, and stretching the nervous filaments spread thereupon: or by such ingesta as are either acrimonious when first taken, or turn so during their stay in the stomach, especially where digestion is weak and slow, pricking the acutely sentient inside of the stomach. These two causes, which are seldom separated, mutually promote and strengthen each other. Irritation from acrimony, creates spasms, and pens up flatulent matter; which, by being so pent up, both becomes more acrid and more rarefied, whereby both irritation and distension are increased. Of this nature are the stomach pains, which occur so frequently in nervous cases, where the digestion is for the most part languid.

As to the cure, acrimony is carried off by diluting the acrimonious matter, and, as it were, sheathing it by warm, watry, mucilaginous liquors. Hence chicken, or veal broth, is an excellent remedy in some pains of the stomach. It is, likewise, destroyed by it's opposites. And as the acrimony that produces such pains in the stomach as we are now treating of, is most commonly of the acid kind, antacids are here chiefly beneficial, as all terreous absorbent powders, lixivial, or volatile alkaline salts, &c. Spasms are relieved by infusions, decoctions, or distilled waters of warm carminative vegetables, and their chemical oils; by foetid gums;



gums; volatile animal salts, or spirits, &c. and **L E C T. XV.** most powerfully of all by opium, which, in violent cases, is indispensibly requisite. At the same time, a prudent cleansing of the primæ viæ, by gentle vomits and aperients, is not to be neglected. To prevent relapse, concoction is to be strengthened by a course of stomachic medicines, appropriated to the particular case, with suitable exercise, and a rightly regulated diet.

Pains in the stomach, and these in a violent and terrible degree, are created by some kinds of poison; to wit, the corrosive kinds, as sublimate mercury and arsenic. This the prudent practitioner will not lose sight of. And, likewise, by other uncommon causes; as schirrous, or cancerous tumors in it's membranes, worms, &c. For a detail of which, we must refer you to practical writers.

We shall conclude with laying before you some general rules concerning diet.

If one is troubled with sour belchings and heart-burn, the proper diet in such a case, is that wherein the animal kind is predominant. But if he is infested with noxious eructations and nauseousness, and throws up stuff that will burn in the fire like oil, a diet containing a large proportion of acefcent vegetables, with a sparing quantity of butter or oil, is required.

To those that live a sedentary life, such foods as demand the least action of the stomach to subdue them, are recommended. Good fresh broth; bread well fermented and baked; tender young meats, with spicy seasoning; and light fermented liquors, in moderate quantity, chiefly constitute this class.

On the other hand, such as labour hard require aliments of more difficult digestion, as brown bread little fermented; stiff puddings; with a moderate quantity of animal food, and that tough and hard, as smoked beef, bacon, dried fish, &c. The diet

LECT. XV. used by the luxurious and delicate, would soon render them plethoric, and throw them into fevers.

Wine, and fermented liquors of all kinds, when moderately used, temper and correct high and rich meats, especially fish, which have a more immediate and stronger tendency to putrefaction, in a general way, than flesh.

Those animals that feed on vegetables are, generally speaking, safer for constant use than those that live on other animals, as their flesh and juices are less inclined to putrefaction, and therefore have a lesser tendency to bring on fevers, or an alcalescent degeneracy of our blood and humors.

### LECTURE XVI.

*Of the pancreas and it's juice. Of scirrhus there. Of the omentum. Of the spleen and it's diseases. Of the liver and bile. Some diseases thereof.*

LECT. XVI. HAVING, in our last lecture, discoursed on the action of the stomach, order would seem to require, that we should next proceed to explain that of the intestines. But as the pancreatic juice and bile, which have a large share in chylification, the theatre whereof is the intestinal tube, are poured into it's beginning, a few inches from the pylorus; it will be most commodious now, to take into consideration the parts that are employed in the preparation of these two liquids.

Of the pancreas. The pancreas, or sweet bread, so called because it is all a fleshy substance, *πανεας* is a long, whitish, tender, and friable glandular mass, situated behind the stomach and spleen, under the liver. Beginning at the spleen on the left side, it stretches transversely cross the vertebræ; and with it's other extremity, is connected with the duodenum. In the human adult subject, it is about seven or eight inches long, and one or more thick. It's end at the spleen is smallest. and it grows gradually broader, as it

+ lola (aro)

approaches to the duodenum, where it terminates. **LECT. XVI.**  
 It hath arteries from the cæliac. It's veins run into the splenic vein, which opens into the vena portarum. It's nerves come from the par vagum; and as they are but small, it hath but little sensation.

It's structure is exactly the same with that of the salivary glands, consisting of small round acini, or glandular knots, connected together with much cellular texture. From each of these there is a small duct, sent out towards it's middle. All these ducts open into the principal duct, which runs along it's axis all it's length, and opens into the duodenum, five or six inches from the pylorus, at the same place with the biliary duct.

As the structure of the pancreas is the same with that of the salivary glands, so it's juice perfectly resembles saliva in every property; and therefore, may fairly be presumed to have the same use, viz. to dilute, open, and dissolve the alimentary mass, and render the chyle to be made out of it, more similar to animal nature. As it is considerably larger than all the salivary glands put together, and situated in a warmer place, it's succus must far exceed the saliva in quantity: **HALLER** thinks it may be reckoned triple. It is propelled into the intestine by the common impetus and course of the circulation, assisted by the pressure of the adjacent parts upon it, in breathing. It is poured into the gut at the same place with the biliary duct, as we have said, that it may be immediately mixed with, in order to dilute and temper the bile, which is both thicker and sharper than itself.

Some authors in the last century, the chief of whom was **SYLVIUS DE LE BÖE**, imagined that these two juices, when mixed in the duodenum, effervesced together; and, from this false principle, deduced conclusions equally false, both with respect to the animal œconomy, and the nature of diseases. But a sounder chemistry hath long ago shewn, that



LECT. they are neither acid nor alkali, nor effervesce ei-  
 XVI. ther with acids or alkalies, or with one another; and  
 therefore their doctrine is now universally exploded.

As we daily observe the salivary glands about the chaps become schirrous, the pancreas is not seldom affected in the same manner; much oftener than is commonly thought, as that distemper is almost always overlooked. It shews itself first by an unusual obstinate costiveness, with a sense of fulness in the region of the pancreas. If in process of time it degenerates into cancer, shooting pains are felt in the affected part, which are exasperated by fulness of the stomach, and are commonly mistaken for pains in the stomach. By degrees, digestion being perverted through defect of the salutary juice, the patient pines, becomes hectic, and dies. This disease, as I have said, is seldom thought on till it is incurable. If it were discovered early enough, no doubt it might be cured by the same remedies that dissolve other schirrosities. Soap here is a valuable medicine, as it not only is an excellent solvent, but likewise supplies the place of the natural juice, by exerting a similar agency in digestion.

The liver is the organ that immediately prepares and separates the bile. But as the omentum and spleen appear to be subservient to the functions of that vast viscus, we shall treat of them first.

The omentum, or cawl, in Greek *επιπλουν*, is a broad membrane, thin and transparent, tender and easily torn, arising from the inferior and anterior border of the stomach, and falling down commonly as low as the navel; sometimes much lower; then doubling backwards and upwards, is connected with the intestinum colon, under the stomach, thus forming an empty bag. This is the omentum majus, and commonly called omentum simply, by way of eminence. There are other lesser omenta of the same structure and use; but with respect to the chief omentum, in-

con-

considerable; and therefore we shall confine ourselves to it. Besides its principal connexions with the stomach and colon, it is likewise attached to the duodenum, to the spleen, pancreas and mesentery. It lies immediately under the peritonæum forwards, being a production of it's cellular part; and covers part of the stomach; and the greatest part of the anterior surface of the intestines.

It is every where a double membrane; I speak not of it's great fold already mentioned; but every portion of the thin membrane, by itself, may be divided into two thinner membranes or sloughs, which are joined together by a thin cellular texture, in the cells of which the fat is deposited. The secretion here is performed in the most simple manner; there being no other apparatus, besides arteries, veins, and pinguedinous ducts, leading to the cells or vesicles. The fat is distributed in the omentum very unequally, as you may find it in some places as thin and transparent almost as the slough of an onion, and in others an inch thick of fat. In corpulent persons it contains a vast quantity of fat, and hath been known to weigh thirty pounds; though commonly it scarce exceeds half a pound. It hath it's arteries from the cœliac; it's veins terminate chiefly in the splenic branch; and all of them ultimately in the vena portarum.

The uses of the omentum are first to ~~inter-~~ *be interposed* ~~pose~~ between the peritonæum and the intestines, and part of the stomach; that all these parts may be preserved warm, moist and slippery, and hindered from growing together. And secondly, to furnish oily matter for the bile. The fat, though it is deposited in the cells of the omentum, and stagnates some time there, yet must have some kind of circulation; otherwise it's store would be continually augmenting beyond measure; and as there are here no other excretory ducts but veins, and these all terminate in the vena portarum,

LECT. which goes to the liver, carrying into it's organism  
 XVI. part of that blood, from which bile is to be separated, it seems plain that the omentum must be one of the chief sources of the oily matter of the bile. The stomach, spleen, and pancreas, which send the other branches to the vena portarum, are in a manner destitute of fat: and as bile abounds with oil, as we shall see by and by, it naturally follows that it must be in a great measure supplied with that oil from the omentum; though no doubt the mesentery and mesocolon contribute some share, as shall be observed afterwards.

The fat of the omentum, which is likewise to be understood of that on the mesentery and mesocolon, as it stagnates in some measure in so warm places, will acquire some degree of rancidity; and therefore more approach to the nature of bile. But though it may be said to stagnate comparatively with respect to the blood and most of the other juices, yet certain it is, that it undergoes a sort of circulation, and is resorbed by veins; as appears in persons, who by distempers or famine are reduced from corpulency to leanness. ~~And in making experiments, globules of fat have been seen taken up by veins in live frogs.~~

The spleen is situated in the left hypochondre, that is, under the cartilages of the left short ribs. It is connected with the stomach, colon, the left kidney, and by it's upper part with the diaphragm. Its situation is changed by the fulness or emptiness of the stomach. It follows the motion of the diaphragm; and is affected by the inflation or subsidence of the colon. In general it is placed upwards and backwards from about the middle of the short ribs on the left side. In it's natural and sound state, it is about six or seven inches long, about three in breadth, and one in thickness; and of an irregular somewhat oval figure; and of a dark livid colour.



It receives arteries from the coeliac. These en-  
 tering it's substance, are divided into innumerable  
 branches, and by their evanescent extremities ter-  
 minate in minute veins, forming by their union  
 the splenic vein, which flows into the vena porta-  
 rum. The vessels of the spleen are very large in  
 proportion to its bulk: and yet it hath no excre-  
 tory canal but it's vein. It's nerves are small and  
 few.

LECT. XVI.

After all the enquiries into, and disputes about  
 the intimate structure, as well as uses of the spleen,  
 it is found to be entirely vascular; without any  
 glandular follicles or cells; or any thing else but a  
 tender cellular texture, to support it's vessels, and  
 connect them together. And therefore it's chief  
 use can scarce be any other, than to divide and at-  
 tenuate by the minuteness of the tubuli, which  
 compose its substance, the blood that runs into,  
 and flows through it. And as it is situated imme-  
 diately under the diaphragm, hard by the stomach,  
 and is subjected to the pressure and action of the  
 abdominal muscles in respiration, the agitation it  
 must necessarily undergo, will accelerate the motion  
 of the blood through it; which otherwise would be  
 over-flow, upon the account of the vast excess of  
 the sum total of the diameters of it's small vessels,  
 above those of the trunks that furnish them. This  
 agitation likewise concurs to comminute and di-  
 vide the blood flowing through it, and thereby ren-  
 ders it fit to temper the sluggish mass sent from  
 the omentum and mesentery into the vena porta-  
 rum; and expedite the secretion of the bile in the  
 liver.

The spleen having but small and few nerves be-  
 stowed upon it, as we have said, can have but  
 little sensation. It cannot be liable to true schirrus  
 or cancer, as it's structure is entirely vascular, no  
 wise glandular. It is scarce susceptible of inflam-  
 mation or suppuration, as the motion of the blood  
 through

LECT. through it is languid, upon the account of the numerous divisions and subdivisions of it's vessels.

XVI.

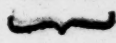
But it may be, and no doubt often is obstructed by viscidities of juices; and so being rendered more or less impervious, may render the secretion of the bile in the liver faulty and imperfect.

Flatulencies in the turn of the colon, near the region of the spleen, are oft mistaken for distempers of the spleen itself.

The liver is by much the largest of all the viscera in the body. It is situated in the abdomen, immediately under the diaphragm. It is of an irregular shape. It's right part fills almost all the right hypochondre, in an adult body, when sound, reaching commonly no lower than the short ribs. In the foetus it is bigger in proportion to the rest of the body, in all it's dimensions. It's middle part lies in the epigastrium, or the region over the stomach: and it's left lies in the upper part of the left hypochondre, not reaching so far down as the right. ~~Some of it's exterior parts are~~ smooth and convex, humouring the concavity of the diaphragm. It's under part is concave, on the right side answering to the colon before, and the right kidney behind. It's middle part, in which the vesica fella is placed, lies over the duodendum, which touches the gall bladder. It's left part covers the stomach. It is thick in it's middle and upper substance; towards it's sides it grows slenderer; at length terminating in a sharp, and as it were, cutting edge. By a furrow in the inferior or concave part, which receives the umbilical vein on it's anterior part; and by another answering to that backwards, reaching to the posterior limits of the liver, which receives the venous duct, (both which canals, to wit, the umbilical vein, and venous duct, are pervious vessels in the foetus, but in the grown animal degenerate into ligaments) the liver is divided into two unequal parts called lobes, the

right

*It's superior part is*

right being much larger than the left. There is LECT. XVI.  
besides a small lobe in it's posterior (concave) part, commonly called the lobule of SPIGELIUS.   
There is likewise a tranverse fossa or furrow, running along the middle of it's concave and under part, in some measure separating it's anterior and larger, from it's posterior and smaller part. It is attached to the diaphragm, and it's weight is in some measure supported by ligaments from that muscle, which are productions from the peritonæum, where it lines its concave surface, and is united by other such productions with the neighbouring parts.

It hath arteries chiefly from the coeliac; and some small twigs from the mammary, the phrenic, the renal and capsular arteries. It is furnished with two kinds of veins, totally differing from each other, which cannot be truly said of any other part in the whole body; to wit, the vena portarum, and it's branches distributed through the substance of the liver, which perform the office of arteries, carrying blood into it; and the other veins, which carry blood out of it, emptying themselves into the vena cava, like the rest all over the body.

The vena portarum is formed by the conflux of all the veins, which return the blood from the stomach, omentum, spleen, pancreas, intestines and mesentery; and answer to the coeliac, and mesenteric, both superior and inferior, arteries. It is worthy of observation that all this venous system, which by it's union constitutes the vena portarum, is unfurnished with valves: so that from it's trunk it may be injected backwards to the minutest origins of small veins in all these parts just now mentioned.

The trunk of the vena portarum, thus formed, enters the liver, between two eminences in the little lobe we have mentioned, called by the ancients



LECT. cients *πυλαί*, or portæ; that is, ridges forming a  
 XVI. narrow channel, or streight betwixt them. As

soon as it is formed into a trunk, it is found to have got stronger membranes or walls than other veins; and even tougher than the aorta itself; formed of a compacted cellular texture, but without true muscular fibres, as BOERHAAVE, trusting to some anatomists, contends. This new and extraordinary strength of coats the branches of the vena portarum carry with them throughout all the substance of the liver; and they are distributed from trunks into branches smaller and smaller, in the same manner as arteries are in other viscera.

Thus is blood brought into the liver, to wit, by arteries called hepatic, of the common sort; and besides by the vena portarum, furnished with the strong coats, and performing the office of an artery, the only instance of that kind in the whole body. The ultimate capillary branches, both of the hepatic arteries and vena portarum, terminate in minute venous twigs, which arising all over the substance of the liver, and forming larger and larger branches by uniting together, at length open, by several large mouths, into the vena cava about the posterior and gibbous part of the liver.

The liver is supplied with nerves from the intercostal and par vagum. They are but small in proportion to it's vast bulk; and therefore it is not liable to violent pains.

The minute intimate structure of the liver is obscure, and hath given occasion to disputes. That it consists of acini or small knots, in which the secretion of the bile is made; and that in these acini the extremities of the hepatic arteries, and vena portarum, and the beginnings of the hepatic veins, and of the biliary ducts, unite, and in some manner anastomose, is acknowledged on all hands; but is the bile secreted solely from the ultimate branches of the vena portarum, and no wise from these

these of the hepatic arteries? Are there glandular folliculi within these acini, into which the new secreted bile is poured, as into so many little cisterns; and from thence derived into the first beginnings of the biliary ducts? These are the two principal problems which must be solved, in order to clear up the functions of the liver, and the secretion of bile. We shall begin with the latter.

LECT.  
XVI.

To prove that there are no such follicles within the small acini in the liver, or at least to shew that we have no good reason to think there are, we need only call to mind what hath been said, when we treated of secretion; to wit, that though the most simple glands evidently consist of follicles, and ducts arising from them, yet no follicles can be demonstrated in the compound sort, whether conglobate or conglomerate, of which latter kind the liver is; and therefore to suppose their existence, is to beg the question: that RHUYSCH by his injections hath shewn, the acini in glands to be entirely vascular, as far as our senses, even assisted by microscopes, can reach: that morbid appearances in glandular parts prove nothing in favour of follicles, as their seat may be, and most probably is, in the cellular texture that connects the acini, and not in the substance of the acini themselves. Upon these strong considerations the system of follicles, broached and supported by MALPIGHIUS and his followers, is now almost universally abandoned; and the vascular doctrine of secretion in the compound glands adopted. See RHUYSCH's letter to BOERHAAVE; in which the acini of the liver are treated of at large. So that we may lay it down as a proposition worthy of our assent, that the secretion of bile in the liver is performed entirely in the vascular way, without the intervention of follicles.

With respect to the other question; to wit, whether the bile is separated from the blood, brought into

LECT. into the liver by the vena portarum, or from that  
 XVI. of the hepatic arteries, let it be observed, first, that  
 the principal artery that goes to the liver, (therefore  
 called hepatic, by way of eminence) is but small in  
 proportion to the vast bulk of that viscus; not even  
 so large as the splenic artery: and the other arterial  
 branches are but inconsiderable. Secondly, that  
 the vena portarum, which is much larger than all  
 the hepatic arteries put together, acquires at it's  
 entry into the liver, as hath been said, the thick-  
 ness and strength of arterial coats. Now this new  
 fabric would appear useless, unless it were destined  
 to fit it for a considerable and uncommon function,  
 which here can scarce be any other than to carry on  
 the secretion of bile. Thirdly, injections into the  
 vena portarum, flow into the biliary ducts and the  
 vena cava, which, as far as I can learn, cannot be  
 said of the hepatic artery; and in a live animal,  
 after tying the hepatic artery, the secretion of the  
 bile goes on abundantly well. Upon these conside-  
 rations, it is not to be doubted, that the secretion  
 of bile in the liver is carried on chiefly, and most  
 probably solely, through the channel of the vena  
 portarum; and that the hepatic artery, and other  
 less considerable arterial twigs, that are distributed  
 to the liver, are destined only for the nutrition of  
 that vast viscus; in the same manner as the bron-  
 chial arteries nourish the lungs, while their princi-  
 pal function, to wit, the trajection of the blood  
 through them into the heart, is effected by the pul-  
 monary artery. This conclusion will be still far-  
 ther confirmed, if we observe, that the arterial  
 blood, which comes to the liver, hath nothing in  
 it's nature peculiarly adapted for furnishing the  
 matter of the bile, as it is derived from the aorta,  
 not far from the heart; very little, if at all, dif-  
 fering from that in the left ventricle; whereas the  
 vena portarum receives the reflux blood from the  
 stomach and small intestines, fraught with a thin  
 sapo-



saponaceous liquid, taken up by absorbent veins LECT. XVI.  
 there, is supplied with oil from the omentum and  
 mesentery; so indispensibly requisite to constitute  
 bile, which contains much oil, and with attenuated  
 blood returning from the spleen: and lastly, hath  
 it's mass impregnated by the putrid tincture and  
 halitus of the fæces from the thick intestines, fit to  
 impart some degree of sharpness and rancidity to the  
 secreted liquid.

Having shewn that it is, at least, highly reason-  
 able to believe that the bile is separated from the  
 blood, brought into the liver by the vena portarum,  
 and not from that flowing through the hepatic ar-  
 teries; and that it's secretion is brought about by  
 an apparatus purely vascular, without the interven-  
 tion of follicles, we proceed in our account of the  
 functions of the liver.

In the acini the extremities of the branches of the  
 vena portarum, and of the hepatic arteries; the  
 beginning of these veins within the liver, which  
 empty it's reflux blood into the vena cava, and  
 the beginnings of the biliary duct; all these meet  
 and concur; by their confluence, and, as it were,  
 adunation, forming each acinus into a roundish  
 figure. The extreme branches, both of the vena  
 portarum and hepatic arteries, are continued to, or  
 anastomose with the beginnings of the veins that  
 open into the vena cava. But those of the vena por-  
 tarum are likewise continued to, or anastomose with  
 the beginnings of the biliary ducts, which does not  
 appear to be the case with the extreme branches of  
 the hepatic artery; as hath been already said. So  
 that the liver is a congeries of branches of the vena  
 portarum; of the hepatic arteries; of the venous  
 twigs, that go to the vena cava; of the biliary  
 ducts; and of the veins themselves; which being  
 it's secretory structure, consist of the evanescent ex-  
 tremities or beginnings of all these, united together  
 by a subtile cellular texture. To which let us not  
 omit

LECT. omit adding the nervous twigs distributed through  
 XVI. it, however inconsiderable in bulk they are, in re-  
 spect to the other constituent parts.

The biliary ducts all over the substance of the liver, by their repeated union and conflux, form larger and larger trunks; which at length make up one great duct, called the hepatic. This, on it's way towards the duodenum, receives another duct, called the cystic, which being united with it, they together form the ductus communis cholidochus. This accessory canal, coming from the vesica fellis, or gall-bladder, we ought here to give a brief description of ~~it~~ *the latter*.

It is a pretty large hollow vessel, or receptacle, nearly of the shape of an oblong pear; situated in a fovea, or pit, in the anterior concave part of the right lobe of the liver, reaching transversely from before backwards; attached to the liver in different places, by a cellular texture; covered over in it's under part, by a portion of the membrane of the liver, which reaching beyond it, keeps it fast in it's situation. Under this, all over it's surface, is a cellular texture; next to that, a thin muscular coat, consisting of pretty conspicuous longitudinal, oblique, and circular fibres; under that a second cellular; then a nervous; and, innermost of all, a villous coat; altogether in the same manner as in the stomach and intestines. There are likewise, especially in it's smaller part or neck, pores, which yield a mucous juice, to defend it against the acrimony of the bile. From the same small part is produced it's duct, which we have just now mentioned: this duct stretching towards the left, is inserted into the hepatic duct, with a very acute angle, near the portæ or πυλαί.

The use of the gall-bladder is, to receive from the liver, by this duct, it's bile, there to be retained; until it be squeezed back again by the pressure of the distended stomach, and action of the diaphragm  
 into

into the ductus cholidochus, and thence into the L E C T. duodenum. By staying there the bile is rendered XVI. thicker, some of it's aqueous parts being resorbed by the inhaling vessels of it's villous coat, and therefore stronger, and of a more saturated yellow. It likewise becomes more sharp, bitter and rancid, by the heat of the contiguous and circumjacent parts.

That the bile in the gall-bladder, commonly distinguished by the name of bilis cystica, is not separated by it's proper glandular structure, but sent into it from the liver by the hepatic duct, is proved by undoubted experiments. If the proper duct of the gall-bladder, called for shortness the cystic duct, is tied, no more bile is accumulated within it than was before. The same happens, if the passage of that duct is stopped up any how, as by a stone in the gall-bladder obstructing it's entry: and an easy compression of the liver, makes gall or bile flow into it.

While the stomach is empty, the gall-bladder is at liberty to be distended and filled, and therefore becomes fullest after long fasting; and the fuller it is, the less compression from the stomach is required to squeeze the bile out of it. So that the more we are prompted to eat, and stuff the stomach by violent hunger, the greater quantity of bile will be poured into the duodenum, by the swelling of the stomach during digestion, to promote so much the more effectually the coction of the aliments; and the cystic bile will be the sharper and stronger, by having remained so much the longer in the gall-bladder.

So that the duodenum receives two sorts of bile, flowing into it through the same canal; to wit, the hepatic, fresh secreted from the liver, which has never been in the vesica fellis, but goes streight on into the intestine; and the cystic.

Both biles are, in the main, of the same nature and properties, differing only in degrees of them.

Q

info-



LECT. infomuch that many species of animals have no  
 XVI. gall-bladder, and therefore, are only furnished with  
 hepatic bile; as, amongst quadrupeds, the elephant,  
 horse, ass, and deer: amongst birds, the ostrich,  
 whose digestion is so strong, the stork, and the  
 pigeon: not to mention some fishes.

As the cystic bile only can be had in large quantities, in order to be subjected to examination, because the other flows constantly and directly through it's duct, into the duodenum, we shall describe it's principal properties, as far as they relate to physiology; which may be applied to the hepatic, making allowance for inferiority of degrees in the latter.

It is a fluid somewhat viscid; coagulable by heat, and alcohol; of a saturated yellow colour, inclining to green; extremely bitter; the sharpest, and most stimulating of all the circulating humors of the body: neither acid nor alkali when fresh; but strongly inclining to, and quickly susceptible of putrefaction; and promoting that disposition in whatever substances it is mixed with, if they are capable of it: it mixes readily with water; it flames not in the fire, unless it be dried, and then it burns almost all away. It is a powerful penetrating soap in every respect; and therefore it is used by the poorer sort in washing of clothes; and in manufactures, to scower wool, or woollen cloth, of all oily filth, that they may receive the purer dye. It dissolves all gums and resins, being rubbed with them; and painters use of it, for this reason, to dissolve their pigments.

By these properties, when poured upon the alimentary mash in the duodenum, it must effect, first, a more intimate dissolution and mixture of the heterogeneous parts together, as it is readily miscible with water, and renders oil and oily substances so. Secondly, though it is not actually alkali, yet it nearly approaches to being so, and must diminish the acrescent disposition of the chyle, and  
 render

render it more similar to animal nature, which is LECT.  
 alcallescent. And, lastly, by it's stimulating power, XVI.  
 as it is the most acrimonious of all the animal  
 fluids, it no doubt helps to excite the peristaltic  
 motion of the intestines, and thereby promotes con-  
 coction. And as it is purgative like aloes, which  
 it resembles not a little, it assists in the expulsion of  
 the fæces. So true it is, what my lord BACON  
 says, that the bile is *multarum in corpore functionum*  
*est stimulus* \*.

It's great utility is evinced by the operose and  
 extraordinary apparatus, used by nature for it's pre-  
 paration. A venous system is fashioned into an  
 arterial one, a contrivance no where else found in  
 the animal structure; and the largest bowel in the  
 whole body is framed to separate and perfect it.

We shall touch briefly upon some diseases of the  
 liver.

It is liable to inflammation and suppuration, like  
 other parts; and, like other glandular organs, it  
 is not seldom schirrous; and therefore, no doubt,  
 may sometimes become affected with cancer: with  
 respect to which diseases, we must refer you to prac-  
 tical authors.

If the liver is obstructed in such a manner, as that  
 the bile, already formed and strained off from the  
 blood, brought to it by the vena portarum, instead  
 of proceeding towards the duodenum, is forced into  
 the small venous canals, that convey the reflux  
 blood into the cava; in that case jaundice is pro-  
 duced, the bile tinging the juices yellow; which  
 change of colour first shews itself in the white of  
 the eye.

Jaundice is produced by a multiplicity of causes,  
 and therefore differs in degrees of intenseness of  
 colour, obstinacy, and malignity, or danger. In  
 general, these kinds, in which the large biliary

LECT. ducts only are plugged up with viscid mucus, or  
 XVI. otherwise obstructed, are the safest and easiest to be  
 removed. And, on the other hand, those in which  
 the secretory structure itself is affected by schirrus,  
 or imposthume, are the most fatal and dangerous.

Calculi are often found in the gall-bladder; concerning which consult an excellent paper in the Memoirs of the Paris Academy of Surgery.

## LECTURE XVII.

*Of the action of the small guts, and chylickation.*

LECT.  
 XVII.

WE have, in a former lecture, treated of the structure and function of the stomach; and shewn, that the digestion of our aliments in that bowel, is not effected by any one cause solely, or even chiefly, as some authors, both ancient and modern, would have us believe, but by many causes concurring; to wit, moisture, heat, maceration, solution, some kind or degree of fermentation and putrefaction, mixture of fluids already assimilated to our nature; as the saliva, and the liquids supplied by the coats of the stomach: and lastly, by mechanical pressure and agitation. And it appeared, that the ultimate tendency of all these causes is, to comminute and dissolve the alimentary mass; to mix all it's parts intimately together; to rendering the whole more homogeneous, and more similar to the circulating animal juices, with which it's finest and most elaborate parts, called chyle, are shortly to be blended and united.

And as the pancreatic juice and bile are poured upon this mass, almost as soon as it is sent out of the stomach into the intestinal tube, we next treated of the structure and functions of the organs which separate and prepare these juices, and of their nature and effects upon the chyle. We found the pancreatic juice to be of the same nature and properties, in every respect, with the saliva. That the  
 bile



bile is likewise a saponaceous fluid, but more sharp L E C T. XVII.  
 and penetrating, and tending more to putrefaction XVII.  
 than the other. That they are both poured into  
 the duodenum at the same place, and so are im-  
 mediately mixed together, tempering or correcting  
 one another. And lastly, besides promoting the  
 same ends which we have just now mentioned, that  
 were in part brought about in the stomach, the  
 bile, by it's tendency to putrefaction, serves to di-  
 minish the acescency of the chyle, and, by it's acri-  
 mony and stimulating power, assists in exciting the  
 peristaltic motion of the intestines, and expulsion  
 of the faeces. And this was the subject of our  
 last lecture.

We come now to take into consideration, the far-  
 ther changes the alimentary mash undergoes in the  
 intestines; the preparation, perfection, and distri-  
 bution of the chyle.

The intestines, or guts, are one continued tube,  
 beginning at the lower orifice of the stomach, and  
 terminating at the anus; but making so many  
 windings and circumvolutions, as to be generally  
 six or seven times longer than the body they belong  
 to. Anatomists have distinguished this tube into  
 two different species of intestines; to wit, the te-  
 nuia or small guts, and the crassa or thick ones.  
 And each of these are subdivided into three portions,  
 to which particular names are assigned. The three  
 small are called duodenum, jejunum, and ileum;  
 the three thick cæcum, colon, and rectum.

*have been*

This bundle of intestines, to use WINSLOW's  
 words, is not left to move at random in the cavity  
 of the abdomen, but artfully tied down by a mem-  
 branous web; which prevents it's circumvolutions  
 from being entangled in each other; at the same  
 time allowing them a gentle floating, but limited  
 motion. That part of it which is connected with  
 the small intestines, is called mesentery; the other  
 part is fastened to the colon, and therefore termed

L. E. C. T. mesocolon. The rectum, having a particular membrane allotted to itself for fixing it, is not here interested. XVII. This membranous web, (for the mesentery and mesocolon are one continued membrane) is a double production of the peritonæum, arising from the vertebræ of the loins. It's two laminae are joined together by a cellular texture, in which the lacteals, blood vessels, &c. run, and the mesenteric glands are placed. When this double membrane hath arrived at the intestines, it's laminae separate, and quite surround them, thus furnishing their external covering.

The intestines, in the main, are pretty much of the same structure, and have the same membranes or coats with the gullet and stomach; to wit, besides the outermost from the peritonæum or mesentery, an exterior cellular texture; under that the muscular coat, consisting of circular and longitudinal fibres; of which the former are by much the strongest: next to this a second cellular membrane; under which is a strong nervous coat, which, as in the stomach, so here makes the principal strength of the tube: then succeed a third small cellular texture; and, innermost of all, the villous coat. But the villi in the intestines, especially the small ones, are much more conspicuous than in the stomach, being longer, thicker set, and covering a greater portion of the tube. This villous coat is much larger than the other coats, almost all over the intestinal tube; but remarkably so in some parts of the small ones, and makes frequent folds and furrows. And as the nervous coat, with the cellular under it, rises, in some measure, in these folds with the villous, it must of course be somewhat larger than the more exterior ones.

The villous, or innermost coat of the intestines, besides the pancreatic and biliary ducts already mentioned, is pierced through by the orifices of tubuli of different sorts: 1<sup>st</sup>, by the extremities of the very small

small vessels, that make up part of the villi, LECT. XVII.  
 whether arterial or venous; and by other such open-  
 ing into the cavities of the intestines, in the inter-  
 stices between the villi, by which inhalation and  
 resorption is kept up here, as well as in all other  
 cavities of the body. 2dly, By the orifices of the  
 lacteal vessels, of which we shall treat particularly by  
 and by. 3dly, By glandular outlets, which furnish  
 a mucilaginous liquor, to defend the extremely  
 sensible internal surface of the tube, against the acri-  
 mony, or otherwise hurtful qualities of what we  
 may take in, and for lubricating it for the propul-  
 sion and expulsion of the fæces. These outlets are  
 of different sizes; some larger, and easily visible  
 by the naked eye. Such come from the glands, de-  
 scribed by BRUNNER in the duodenum, and by  
 Peyer in the jejunum and ileum. These are ga-  
 thered into clusters at various distances from one  
 another; their seat is in the cellular membrane,  
 between the villous and nervous coat, and their out-  
 lets piercing through the former, open into the ca-  
 vity of the intestines. They yield a mucous liquor,  
 which may be easily seen by squeezing them, for  
 the purposes abovementioned. In the thick guts,  
 glands of the same kind and use are scattered soli-  
 tary all over their inward surface. Besides these  
 larger glandular openings, there are others ex-  
 tremely minute, not to be seen without nice prepa-  
 ration, and the assistance of good microscopes; mi-  
 nutely described by LIEBERKHUN, in his amazing  
*Dissertation de Villis Intestinorum Tenuium*. These  
 he found all over the small guts, in the interstices  
 betwixt the villi, and traced them to their origin,  
 from proportionably small glandular bodies, seated  
 in the contiguous coat: and, with great probability,  
 concludes them to have the same use with the for-  
 mer; and that, considering their vast number, they  
 supply more intestinal mucus than these do.



**LECT. XVII.** The intestines are plentifully supplied with blood vessels, chiefly from the mesenterica superior, and inferior; and with nerves from the par vagum, and therefore are most acutely sentient. Hence the violent pains in some of their diseases.

Having observed these things concerning the intestines in general, we come to take a more particular view of the small ones, in which chylication, the subject of our present discourse, is chiefly, and almost solely brought about.

The first of these, called duodenum, because it is supposed to be twelve fingers breadth in length, is wider than the rest; as it receives all the mass expelled out of the stomach, which cannot be said of the other guts, some part thereof being resorbed by the way; but chiefly upon the account of it's having, for a great part of it's length, from it's origin progressively, no external tough covering from the mesentery, to limit it's size. It is, likewise, redder and more fleshy than the jejunum and ileum, it's muscular fibres being thicker and stronger. About it's middle it receives the pancreatic and biliary ducts, which passing through it's coats, obliquely open into it by one orifice. It makes several curvatures; the most considerable is that by which it ascends almost perpendicularly some way, soon after the two ducts open into it's cavity, whereby the alimentary mass must needs be somewhat retarded in it's passage through it, and the bile and pancreatic juice the more thoroughly mixed therewith, and with one another. In it's beginning, it's innermost coat is even, without wrinkles or furrows; such as are called valvulae conniventes; but in it's progress, and towards it's terminations, it gets many such; which must farther retard the passage of it's contents. It is supplied with arteries, chiefly from the same trunk that supplies the stomach, to wit, the celiac. Some lacteals, though but few, arise from it.

The

The second of the small intestines is called jejunum, because it is oftener found empty, as is pretended, than the duodenum or ileum. And if it is not easy exactly to fix the limits between the duodenum and it, it is no less difficult to determine precisely where the jejunum ends, and the ileum begins. One way of distinguishing them, and perhaps the best, is to call all that jejunum, whose circumvolutions are above the umbilicus, and whose cavities are remarkably furnished with rugæ or valvulae conniventes. This will bring it to be about a third shorter than the ileum. It is narrower than the duodenum; it's muscular fibres are thinner and weaker; it hath some clusters of PEYER's glands, and sends forth very numerous lacteals.

The ileum makes it's windings chiefly below the umbilicus. The lateral foldings are supported by the ossa ilea; from which situation probably it hath got it's name. It's structure is much the same with that of the jejunum, except that in it the valvulae conniventes decrease gradually, both in number and size, till at length they disappear. It hath more of PEYER's glands than the two former, especially about it's termination, and sends forth extremely numerous lacteal vessels, the jejunum and it furnishing almost the whole of these canals. It is considerably longer than the jejunum, as hath been said, and is continued to the colon. Both the jejunum and the ileum are furnished with blood vessels from the mesenterica superior.

Having described the small intestines, which are the instruments immediately employed in the making and perfecting of the chyle; before we explain the way and manner in which that important work is carried on, it will be proper to take into particular consideration the lacteal vessels, and other such minute tubuli, as either pour liquids into the cavity of the intestines, or resorb from it, and have not, as yet, been fully enough treated of.

And

**L. E. C. XVII** And first, let us observe that warm water, or even ceraceous matter, can, without great difficulty, be injected into the cavity of the guts, either by the mesenteric artery, or mesenteric vein. This experiment shows, that there are direct ways, by which liquids can both be poured into the intestines from the contiguous parts, *ab extra*, and be resorbed from their cavity.

As the ancients knew nothing of the lacteal vessels, or chyliferous ducts, they fancied that all the chyle was taken up by the meseraic veins, (another name for the mesenteric) and from thence sent into the vena portarum and liver. And so far they were in the right, that without doubt some part of it must go that way, and probably a great part of our drink, that course appearing shorter and more expedite than by the lacteals and thoracic duct, into the subclavian vein. All the feathered kind, the ostrich not excepted, are without lacteals, as far as can be discovered; and therefore, as all their chyle must flow in the channel just now mentioned, the analogy of nature would seem to require, that some of our chyle should be distributed in the same manner.

But **ASCELLIUS**, in the year 1622, discovered the lacteals; and about thirty years after, **PECQUET** traced them into the receptaculum chyli, and thoracic duct; and from thence into the subclavian vein. By these discoveries, a course of the motion, and determination of the chyle, before unknown, was clearly and fully laid open.

The late celebrated **Dr. LIBERKHUN**, a Berlin physician, in the before mentioned treatise, by exquisite preparations, and nice management of the solar microscope, of his own invention, hath so unravelled and described the origin of the lacteals, in the villous coat of the small intestines, as far to have exceeded the labours of all other anatomists, **RHUYSCH** himself not excepted. He finds, and shews



shows by his preparations, that to every single vil-  
lus there is distributed one lacteal branch; some  
small arterial twigs; (but such as transmit a liquid  
much more subtle and fine than red blood) and  
a single vein. He adds ~~one or more~~ one or more  
nervous filaments, and that from reason only, be-  
cause the inside of the intestines is exquisitely sen-  
sible; he having been able to trace the nerves of  
the intestines, even by the microscope, no farther  
than the inside of the nervous coat. The lacteal  
vessel, after emerging from the villus, is cylindrical,  
and furnished with valves so near it's origin in the  
villus as the nervous coat: but in it's origin, is ex-  
panded into a vesicular little sphere, or ampullula,  
with an orifice in it's apex, where it opens into the  
villus and cavity of the intestine.

By his finest and most successful injections, he  
discovers extremely small arterial twigs, running in  
a serpentine manner upon the outer surface of these  
ampullulae, and that some of them open into their  
cavities; he having filled these ampullulae with co-  
ruscous matter, injected by the mesenteric artery,  
and sometimes forced it through the orifices, in  
their extremities into the cavity of the gut.

These observations are so amazingly minute and  
subtle, that possibly they may scarce gain belief  
from some readers. But the incomparable author,  
besides having an excellent mechanic head, and  
great manual dexterity; was likewise endowed with  
a most acute and penetrating sight; and his moral  
character was so unexceptionable, that I find the  
ablest judges scruple not to give their assent to  
what he writes, relating to his own discoveries.

The lacteals from this their origin proceed, after  
penetrating through the coats of the intestines,  
along the mesentery, and by the frequent union of  
smaller twigs into one, form by degrees larger and  
larger branches; being, during their whole course,  
furnished with valves, which are so constructed, as

LECT. to allow the chyle a free passage towards it's receptaculum, but hinder it's return towards the intestine. But we shall now consider the action of the intestinal tube upon it's contents, and afterwards more particularly describe the course and distribution of the chyle.

To understand which, let us call to mind what hath been said concerning the office of the stomach; and we shall soon perceive that in the intestines, effects of the same kind are produced, but in a higher degree, and with greater energy. The heat indeed of the parts; the agitation caused by the alternate action of the diaphragm, and the muscles of the abdomen; and by the pulsation of the circumjacent arteries are equal, or pretty nearly equal, in both: but in the intestines, they are longer applied to the same quantity of contents, than in the stomach, upon the account of the great length of the former; their manifold convolutions; and their furrows or valves, which detain the contents longer than they are detained in the latter. The bile and pancreatic juice are poured into the intestines, over and above the liquors that come into the stomach. The villi of the intestines are of a more conspicuous structure, thicker set, possessing a greater surface, and therefore much more numerous than in the stomach; so that a greater quantity of an elaborate fluid, already perfected by circulation, may flow through inhaling arterial tubuli belonging to the villi, than into the stomach: and, lastly, the vermicular motion in the intestines is exercised in a constant, energetic, and conspicuous manner, which in the stomach is so languid and inconsiderable, as to have even it's existence called in question.

As this motion is of so great importance in the animal machine, we shall be somewhat particular in describing it, and accounting for it in the best manner we can.

We have mentioned a double plane of muscular L E C T. fibres, with which the intestinal tube is furnished; XVII. to wit, the circular, which are by much the stronger, and the longitudinal. Now it being the nature of muscles to contract, when irritated, in order to rid themselves of the irritating cause; both these planes must be so affected in many different portions of the guts, at one and the same time, according as the alimentary mash in it's progress comes into contact with them. The mash is fitly qualified to irritate, by it's heat; by distension, as it has air mixt with it; and by it's acrimony, especially from the bile: the circular being, as hath been said, the stronger fibres of the two, conquer the other, and render the contraction alternate. Had their force been equal, as their action is contrary, and as they must be irritated at the same time, neither of them could act. The circular, by straitening the canal, propel it's contents; the longitudinal, by widening and shortening it, resist propulsion. But as the former is most powerful, propulsion upon the whole takes place. That propulsion is determined towards the thick guts, for the reasons we assigned when treating of the stomach; to wit, because the pylorus is much lower than the other orifice; because the oesophagus passes between the fleshy fibres of the diaphragm; by which contrivance, the contents of the stomach are hindered from rising towards the mouth in a sound state; the liver, by being in respiration pressed against the widest part of the stomach, on the left side, urges it's contents towards the pylorus; and the valve-like ruga, at the pylorus, extending itself somewhat into the duodenum, favours their passage into the duodenum more than their return into the stomach. By these means, the course of the alimentary mash is determined towards the thick guts; and there being in a sound state, nothing to obstruct that course, the circular fibres  
in



**L E C T.** in the intestines must needs propel their contents  
**XVII.** in that direction. This alternate contraction of  
 these two planes of muscular fibres, is the vermicu-  
 lar motion of the intestines, commonly called the  
 peristaltic motion. But let us not imagine that it  
 is one simple motion, with one direction, it being  
 really a double one, with two opposite directions.  
 The term vermicular is the proper of the two.

It's effects, or use, may be considered as twofold.  
 First, by agitation and pressure, to perfect the mix-  
 ture of the finest parts of the mash together, and  
 to perfect their solution and attenuation; at length  
 producing a thin, white, sweet liquor, resembling  
 emulsion, called chyle. Secondly, to promote the  
 reception of this chyle into the orifices of the lac-  
 teals, and it's propulsion through them towards the  
 receptaculum; at the same time assisting the ab-  
 sorption of other subtile fluids through the venous  
 tubuli, that open into the cavity of the intestines.  
 While a portion of the tube is widened, the orifices  
 both of the lacteal ampullæ, and the other re-  
 sorbing tubuli, are enlarged, and fitted to admit  
 their fluids; and while it is contracting, the fluids  
 are urged on towards their destined places.

This motion goes on in a seemingly irregular  
 manner, in a great many different parts of the guts  
 at once. It never ceases during the life of the  
 animal, and even continues after death; inasmuch,  
 that if the stomach and intestines are cut out of a  
 new killed animal, while it is warm, and laid upon  
 a table, they will appear to move and creep for a  
 considerable time. And this seems pretty well to  
 account for persons recovering, after having ap-  
 peared to be a long while dead: the intestines, by  
 this motion, continue to urge on fresh chyle into  
 the blood, which, by irritating the heart, at length  
 excites new contractions, and sets the blood again  
 in motion.

We

We go on to describe the farther distribution of **LACT.**  
the chyle. **XVII.**

The lacteals, having emerged out of the intestines, proceed running along the mesentery, uniting together, and forming larger and larger trunks as they advance. In this their progress they arrive at, and immerse themselves into certain glands, or gland-like bodies, scattered up and down in great numbers upon the mesentery, from whence they have their name. They are soft and spongy, covered with a cellular membrane, and plentifully furnished with blood vessels, which are distributed through their substance in the most exquisitely subtle manner; as appears from a figure which **RHUYSCH** caused to be drawn from a preparation: this figure is executed with such art, as to require the assistance of a microscope to get a right view of it. See his Answer to **BOERHAAVE**'s Letter on Glands. They have each a pretty large cavity, but no peculiar excretory ducts. Lacteals sometimes plunge into one of these glands, and emerge again, passing on to others in the same manner, immersing and emerging for three or four times. Sometimes they pass by some of them very nigh, without touching at them. Their use is not well known. But as the chyle hath been found more aqueous in the lacteals, after their coming out of these glands, than it was before; and that thin liquors, injected into the arteries that go to them, penetrate into the lacteals, and affect the chyle in them; it is highly probable that they prepare a thin liquor, to be mixed with the chyle, in order to dilute it, to render it less crude, and more similar to animal nature. They are much larger in the foetus than in the adult animal, and in old age they are found shrank almost to nothing. It is therefore to be presumed, that their use is greater in utero, than after birth. But that is common to the whole glandular system, if except those glands that are concerned in generation;

*Here  
Dr Monto  
found a  
Discovery to  
be made*

LECT. ration; as we shall observe when we treat of the XVII. foetus.

After the lacteals have passed all the mesenteric glands, being now become large, by the frequent adunation of smaller branches into larger trunks, and therefore few in number, not above four or five, they at length, by their conflux, form one membranous bag or sac, called receptaculum chyli, variously formed in different subjects, but most commonly, it is one undivided ampulla or vessel, about two inches long. It's situation is hard by the aorta, betwixt it and the right muscular appendix of the diaphragm, and not seldom it is produced above the diaphragm into the thorax. Into this bag, or receptacle, almost all the lymphatic vessels that come from the various parts under the diaphragm, empty themselves; by which means the chyle there is still farther diluted, and the mixture rendered more similar to naturalised animal fluids. By this dilatation of the lacteals into a sac, and by it's situation between the aorta and the appendix of the diaphragm, the one incessantly beating, the other constantly playing in respiration, the mixture of chyle and lymph is effectually forced upwards, contrary to it's gravity, through the canal that arises from it, called the thoracic duct. This canal springing from the upper part of the receptaculum, much narrower than it, and ascending through the length of the thorax, from which course it hath it's name, receives, in it's progress, lymphatics from the oesophagus, stomach, lungs, and, in general, from almost all those that come within the thorax, for the same purposes as those from the inferior parts of the body, flowed into the receptaculum. When it hath advanced as high up as the fifth vertebra of the thorax, it turns from the right side to the left, and ascending behind the left subclavian vein, makes a turn towards it's upper and back



back part, and opens into it at it's conflux with the jugular. LECT. XVII.

Thus we have traced the aliments from their assumption at the mouth, to their being converted into chyle, and sent into the blood. As there are such a variety of actions concurring to promote and compleat this effect, and a variety of organs concerned, it will, we hope, be agreeable, and not un-instructive to the beginner, for whose benefit these lectures are chiefly intended, to throw the substance of this whole doctrine into one methodical, succinct, and not over contracted summary.

And first, our meats after being chewed, and so mixed with air and saliva (the latter a thin saponaceous fluid, remarkably promoting fermentation,) are swallowed down into the stomach, through the œsophagus, where, together with the drinks, which nature prompts us to take in along with them, they are to remain some time, to undergo the changes to be brought on by the action of that bowel, which changes are commonly called digestion.

During their stay in the stomach, fresh saliva is constantly poured upon the mash from the mouth; it being observed, that we swallow down some of it every third or fourth respiration. And the innermost, or villous coat of the stomach, being pierced with arterial tubuli opening into it's cavity, supplies a thin saltish fluid, called liquor gastricus, to be added to the mixture. This liquor, as well as the saliva, is already assimilated to animal nature, having undergone circulation and secretion, and therefore renders the whole less crude, than otherwise it would be.

The alimentary mixture thus composed, were there no other causes applied to it, by remaining in so warm a place, warmer than the atmosphere under the equator at mid-day, would be macerated, the fluid parts penetrating through the more solid, and, in some measure, dissolving such as are susceptible

LECT. of solution; such as are aceſcent would turn acid;  
 XVII. if liable to fermentation, they would begin to ferment; if putreſcible, they would begin to putrefy; heat not exceeding a certain degree, and the preſence of air, neceſſarily promoting theſe changes: and, upon the whole, attenuation, intimate mixture, and rarefaction, muſt needs be produced; the latter being greatly promoted, not only by the common air in the mixture, but by air generated in fermentation, or putrefaction, expanded by the heat of the ſtomach. And hence in diſteſtion the ſtomach ſwells.

But, beſides the effects of heat and moiſture, there are other conſiderations to be taken in. The ſtomach is furniſhed with a muſcular coat, conſiſting of two ſets of fibres of different directions; the one, upon the whole, circular; the other moſtly longitudinal. The former are the ſtronger of the two. If theſe two ſeries act jointly, they muſt cloſely embrace and compreſs the contents, and urge the expulſion of what can be moſt readily expelled. If they act ſeparately and ſucceſſively, there will be produced a kind of vermicular motion, like that in the inteſtines, though much weaker, and leſs conſpicuous, as the muſcular fibres in the ſtomach are much thinner ſpread in proportion to it's capacity, than thoſe of the guts. By this vermicular motion the contained maſh muſt be, in ſome meaſure, agitated, the intimate mixture, the inteſtine motion of it's parts, whether in the way of fermentation or putrefaction, and, of courſe, their attenuation, be ſomewhat increaſed.

But the ſame ends are much more briskly promoted by the action of the muſcles, that are conſtantly employed in reſpiration. When we inſpire, the diaphragm preſſes down the liver upon the ſtomach; when we exſpire, the muſcles of the abdomen preſs up the ſtomach againſt the liver. This reciprocal action, being repeated above a thouſand times

times in an hour in the most sedentary life, must have a very considerable effect in the space between any two meals, to heighten the intimate mixture and attenuation of the alimentary mash, and promote the expulsion of it's most concocted parts through that orifice of the stomach, which yields the least resistance, to wit, the pylorus: and the fuller the stomach is, the greater will these effects be.

Nor is the continual pulsation of the aorta, and other large arteries in the neighbourhood, to be altogether omitted in this account, as a cause conspiring with the other already mentioned. If a few pulses can make little or no impression, yet by their frequency and uninterrupted repetition, some effect, not inconsiderable, must be produced.

By all these operations, which in some measure go on together, the most fluid and most attenuated parts of the contents of the stomach, must be gradually, and in small quantities together, expelled through the pylorus into the duodenum.

This intestine, the first of the small ones, being wider than the rest, and at it's beginnings smooth, and free of wrinkles in it's inside, can there but little retard the passage of what is sent into it. About it's middle (supposing it to be twelve fingers breadth long,) it receives the pancreatic juice and the bile, which open into it's cavity at one orifice, and therefore are mixed together before they make any farther progress. The bile is twofold; to wit, the cystic, the more viscid, bitter, and acrimonious of the two, upon the account of it's remaining some time in the gall-bladder; the hepatic, sweeter, and more aqueous, as flowing constantly from the liver into the intestine: but they agree in their principal properties, being both highly penetrating and saponaceous, and though not actually alkaline, yet tending much that way; quickly susceptible of putrefaction, and ready to promote that disposition in any substances it is incorporated with. The quantity

+ They are



LECT. tity of bile, including both kinds, must be very  
 XVII. large, considering the vast bulk of the liver. By  
 { it's penetrating, saponaceous quality, it farther dis-  
 solves, and intimately mixes the different parts of  
 the alimentary mash together : and by it's tendency  
 to putrefaction, it renders the chyle less acedent and  
 crude than it would be otherwise. The pancreatic  
 juice is, in every respect, of the same nature and use  
 with the saliva, but in much greater quantity, the  
 pancreas being larger than all the salivary glands  
 put together, and situated in a warmer place, to  
 cherish and promote secretion. It serves, besides,  
 to temper the viscidty and acrimony of the cystic  
 bile, as they are mixed together upon their being  
 first poured into the duodenum. So that, with  
 respect to the efficacy of adventitious juices, the  
 alimentary mash is <sup>much</sup> more strongly acted upon in  
 the intestines, than in the stomach.

The coats of the small intestines are pretty much  
 the same with those of the stomach. The principal  
 difference is, first, that the innermost or villous,  
 being in many places of greater extent than the  
 other coats, there are more frequent rugæ, or fur-  
 rows, called here valvulæ conniventes, than in the  
 stomach : the villi are more conspicuous and thicker  
 set. Hence there is occasioned a greater remora  
 to the progress of the contents, and a greater quan-  
 tity of a subtile fluid, answering to the liquor ga-  
 stricus, is poured upon them from the arterial tu-  
 buli, opening into this coat, during their passage  
 through the great length of the circumvolutions of  
 the intestinal canal. Secondly, the muscular fibres  
 are thicker spread upon the walls of the narrow in-  
 testines, than those of the capacious ventricle, and  
 therefore act more strongly. Hence the vermicular  
 motion, called in the intestines peristaltic, is more  
 conspicuous and effective than in the stomach.  
 Moreover, the intestines being so very long, while  
 their cavities are very narrow, this alternate motion  
 of

of widening and constriction in sundry portions of the tube, must needs, by agitation and pressure, produce a greater change on the contents, in point of attenuation and thorough mixture, than can be brought about by the mechanism of the stomach. LECT. XVII.

But this vermicular motion is, besides the principal efficient cause of the propulsion of the finest and most elaborate parts of the intestinal contents, called chyle, into the lacteals. While the longitudinal fibres act in any portion of the tube, that portion is shortened and widened; by which means the orifices of the lacteal ampullulæ, and other absorbent tubuli in that portion, are opened, and their fluids sucked in. And when the circular fibres exert themselves, that same portion of the gut is contracted in it's diameter, and in some measure lengthened; whereby the juices are squeezed farther through the tubuli which admit them, on their way to the blood: at the same time the fæces are propelled towards the thick intestines.

The lacteal ampullulæ, if LIBERKHUN's observations are credited, receive extremely minute arterial tubuli, carrying a liquid much more subtile than red blood, arising from the mesenteric arteries, which open into their cavity. So wonderfully solicitous is nature to mix juices highly attenuated, and thoroughly assimilated to animal nature, with the new-made chyle, to dilute, and render it less strange to the blood, with which it is to be mixed by and by. The lacteal vessels are every where furnished with valves, which allow the chyle a free passage towards the mesentery and receptaculum, but prevent it's being beaten back towards the intestines. In their progress becoming fewer and larger, by small branches uniting into more capacious trunks, they are plunged into the mesenteric glands, emerging again out of them. Within these glands there is reason to believe the chyle is farther diluted and attenuated. From thence in

**L E C T.** their progress they are all united into one large sac, **XVII.** or receptacle, first discovered by PECQUET. Into this receptacle almost all the lymphatics under the diaphragm disembrace themselves, still farther to thin the chyle. From this sac arises the thoracic duct, which ascending through the cavity of the breast, transmits it's liquid to the left subclavian vein, after receiving in it's passage lymph from almost all the parts of the thorax.

From which view of chylication it plainly appears, that one principal intention of nature, through the whole of this important function, is to render the chyle, which is from time to time gradually to be added to the mass of blood, to repair it's waste, and support life, of a piece with, and similar to the mass itself; as almost every thing which is foreign to it, if suddenly mixed with it, is apt to produce dangerous, and even fatal effects.

## L E C T U R E XVIII.

*Of the thick guts, and feces, and some diseases of the intestines.*

**L E C T.** **XVIII.** **H**AVING treated last of chylication, we proceed to consider what becomes of the gross exhausted part, and, as it were, the caput mortuum of the alimentary mass, and explain the structure and functions of the thick intestines.

The ileum, the last of the small guts, terminating near the right kidney, opens into the colon, at it's junction with the cæcum. By the latter name we understand with the ancients not the worm-like appendix, which is too small to be numbered amongst the thick guts, but that short wide sac, the head of the colon, from which the appendix hangs. This sac is about three inches long; it's diameter is about thrice as large as that of the small intestines: it is situated under the right



right kidney, and hid by the last convolution of the LECT. ileum. The appendix, we have mentioned, arises XVIII. laterally from it's bottom, is about the same length, but very slender; it's diameter commonly not exceeding a quarter of an inch. It's termination is shut, and it fluctuates loose.

The colon from it's origin makes a large ~~turn~~ *turn* upwards as far as the liver, then proceeds transversely to the left under the gall-bladder, which it touches; under the bottom of the stomach, towards the spleen, and the left kidney, to which it is fastened; from thence passing, it makes several turns, the whole of them pretty much in the figure of a capital S inverted; then terminates in the rectum. So that it surrounds in a manner the whole abdomen, sometimes ascending, sometimes descending; hence it happens, as BARTHOLIN well observes, that one stool often is succeeded immediately by another: by this contrivance, likewise, the fæces are longer kept, and hindered from being every now and then indecently voided.

The rectum or streight gut, so called, because it's course, if the length of the body is regarded, is streight, though it is bent backwards and forwards, humouring the direction of the os sacrum, and os coccygis, begins where the last curvatures of the colon end, and is terminated at the anus.

After thus describing the general situation and course of the thick intestines, we come to consider each of them more particularly. And we shall first take notice of a remarkable contrivance at the junction of the ileum with the colon and cæcum, by which the contents of the small intestines are allowed a free passage into the thick ones; but all regrefs or retropulsion from the latter into the former is effectually hindered and stopt. This is called valvula Bauhini, from CASPAR BAUHINUS, who hath passed for it's discoverer; sometimes valvula Tulpii, because TULPIUS, in his observations, hath given

LECT. a good description of it; and often *valvula coli*.

XVIII. This valve is constructed in the ~~manner as follows~~.

*+ following manner* The ileum opens into the beginning of the colon, at it's origin from the cæcum, somewhat obliquely, from below upwards, but nearly at a right angle; and opens in such a manner, as to extend itself some way within the common cavity of the cæcum and colon, carrying along with it, and closely united to it, all the coats or membranes of the colon, the most external only excepted. Thus reinforced, the ileum opens into the common cavity of the two thick guts, not with a circular patent orifice, but with a rima, like a mouth, which hath two productions like lips or valves; one lower and larger, towards the cæcum; the other higher and less, towards the colon. Through this rima or mouth, at the opening of the ileum, it's contents, being pretty fluid, easily make their way, shoving aside the valve-like productions; and falling by their gravity into the cæcum, the bottom of which is lower than the opening of the ileum. In the course of the propulsion of the contents of the cæcum onwards into the colon, the inferior valve, being large enough to cover the whole opening of the ileum, is pressed against it, and shutting it effectually, determines the course of the contents past the orifice of the ileum into the colon. The superior and lesser valve, in some measure, prevents the admission of the contents of the colon from above downwards into the ileum; but as the constant tenor of the propulsion of the intestinal contents is from the pylorus to the anus, no doubt the inferior and larger valve is the chief security. And so completely does this contrivance answer it's end, that neither water nor air, thrown into the rectum, can be made to pass into the ileum, without remarkable violence. It's effect in the animal œconomy is very salutary. For as the contents of the intestines begin to putrefy, and become foetid in  
the

the cæcum, by their being retarded there, both LECT. XVIII.  
 upon the account of it's capaciousness, and the al-  
 most perpendicular ascent of the colon it's conti-  
 nuation, if their repulsion into the ileum was not  
 effectually hindered, the chyle in the small guts  
 would be tainted with putridity; and even excre-  
 mentitious matter would often be thrown up at the  
 mouth in obstinate costiveness; whereas not so  
 much as a fæcal halitus can get that way in a state  
 of health; though stools should be wanting for ten  
 or twelve days together, as happens in a common  
 way to many.

The ileum opens into the colon, as hath been  
 observed, at it's junction with, or origin from the  
 cæcum; and that being much wider than the small  
 intestines, and at the same time lower than the im-  
 plantation of the ileum, the contents must in some  
 measure stagnate there; especially as the colon  
 from it's origin mounts in a manner perpendicular-  
 ly, as far as the liver in the right hypochondre.  
 By stagnating in so warm a place, their putridity  
 increases there, and they acquire the fæcal odour,  
 which is not observed in the contents of the small  
 guts. They likewise become less fluid, and more  
 consistent, by the resorption of the more liquid  
 parts through the lacteals, and other bibulous veins,  
 still continuing. That there are lacteals through  
 the whole colon, though much less numerous than  
 in the small guts, yet more frequent than is com-  
 monly believed, the celebrated Dr. SWENKE hath  
 confirmed in his excellent Hæmotologia, by a me-  
 morable observation. A soldier was killed by a  
 musket-shot, soon after eating a plentiful meal;  
 the bullet had destroyed the left clavicle, with the  
 vessels under it, whereby the thoracic duct, near  
 it's insertion in the subclavian, was compressed, and  
 the passage of chyle through it stopt. Upon open-  
 ing the dead body, innumerable lacteals appeared  
 through the whole extent of the colon, to it's ter-  
 mi-



L E C T. mination in the pelvis. From which appearance;  
 XVIII. seen by himself and other physicians and surgeons  
 with him, the author, with his usual judgment  
 and sagacity, infers the great value and utility  
 of nutritive glysters.

The vermicular appendix of the cæcum would appear to be of more remarkable use in the foetus, than in the born animal, it being considerably larger, in proportion to the rest of the body in the former, than in the latter. In the ripe foetus, there is always found more or less meconium in it. But as professor MONRO never found it distended with that substance in any foetus he had opened, he justly concludes, that it's principal use is not so much to serve, as a receptacle for meconium, as by the numerous glandular outlets in it's cavity, to lubricate the membranes and contents of the cæcum, into which it opens, as well as it's own, in order to facilitate the propulsion of the fæcal matter, and prevent it's adhesion to the coats of the cæcum, and it's own, where it must stagnate longer than it had hitherto stagnated any where in the intestinal tract. This use takes place likewise in the born animal; and besides, in obstinate costiveness, by affording more room or stowage for the congested fæces, it renders that complaint more easy to be borne, and less detrimental, than otherwise it might be.

The cæcum and colon, besides having a stronger muscular coat than the small intestines, are furnished with three ligament-like bands, running lengthwise on their outside, dividing their surface into three portions nearly equal. Though these appear like ligaments externally, they are made up in their inner structure of true muscular fibres, and strengthen the longitudinal fibres of the muscular coat. As they are longer than the proper coats, they keep them drawn up into folds or wrinkles.

+ shorter

Through

Through these intestines is propelled and urged on L E C T.  
 the remainder of the alimentary mash, after having XVIII.  
 undergone the action of the small guts. It consists of the terrestrious part of the ingesta; of the membranous, fibrous, cartilaginous, and bony parts, that could not be sufficiently broke and comminuted by the stomach or intestines, so as to be taken up by the lacteal and other absorbing vessels; the recrements of the bile, and mucus furnished by PEYER's glands, all mixed together. The causes of it's propulsion are the same as in the small guts; to wit, the action of respiration, and the peristaltic motion of the intestines themselves. But it's course is slower than in the small guts, upon the account of it's thicker consistence, the ascent and windings of the colon, the remoras it meets with from furrows within the tube, and the great stop from hard fæces in the rectum, pent up by the sphincter ani. The putridity is increased as it goes on; and as putrefaction generates air, the colon is commonly found distended with flatulency. The whole is gradually more and more exhausted and robbed of it's most fluid parts. And, as we mentioned when treating of the liver, what putrid miasmata are absorbed by the mesocolic veins, are determined finally into the vena portarum, to contribute towards the rancidity and putrescent disposition of the bile; so that here even the fæces, which are upon the point of being expelled altogether out of the body, are rendered useful, and made subservient to the perfection of what is left behind.

The rectum begins in the pelvis, where the last curvatures of the colon end. It's muscular coat is much stronger, than in the other intestines. The ligament-like bands, which in the cæcum and colon are collected into three portions, are spread equally over it's surface; a wise precaution of nature, that no part of it may be weaker than another, lest it should give way in the efforts of egestion.

Into

LECT. XVIII. Into this intestine the faecal matter, now consistent, and shaped by the cylindrical cavity of the colon, (especially in it's last curvatures, where it is more uniform, and not so much distended by flatulency) is received, and accumulated therein, until, by it's increased bulk, weight, and acrimony, it becomes troublesome, and would prove hurtful, if longer retained. Then it is expelled by the muscular powers furnished for that purpose: and strong powers they are, and admirably fitted to answer their end.

In the first place, whatever influence the mind or will has over the sphincter ani, to keep it contracted, is discontinued, that it may be the more easily forced open; while the longitudinal fibres of the intestine exerting themselves, make an effort to shorten and widen it, thereby hindering it from being thrust out at it's lower extremity, in which they are strongly assisted by the muscles called levatores ani. These arise, one on each side, with a broad origin from part of the ossa pubis, ileum, and ischium; and descending with converging fibres, embrace the lower part of the rectum, and are inserted into the sphincter ani. From which origin, course and insertion, it is evident, that they pull the rectum upwards, at the same time serving, in some measure, to open the sphincter. While all this is doing, we draw in air with a strong effort of inspiration, and retaining it, by keeping the mouth and glottis shut, we forcibly actuate, at one and the same time, both the diaphragm and muscles of the abdomen, quite differently from what passes in respiration, where they act alternately, and produce opposite effects; but in the function we are describing, they are made vires conspirantes; the colon, rectum, and the contained faeces, by their joint action, being put as it were between two presses. By this effort, with the concurring power of the circular fibres of the rectum itself, the faeces are



are expelled, and the sentient principle set at LECT. ease: which being done, the muscles concerned in XVIII. the effort ceasing to act, by the restitutive power of the sphincter, and the elasticity of the parts, the natural state is restored.

We shall now, agreeably to our plan, touch upon some distempers, whose seat is principally in these parts, the structure and functions of which we have been describing. The first we shall consider is diarrhœa, or looseness.

Diarrhœa is a frequency of over thin stools. If stools are of a proper thickness and consistence, they scarce can be frequent; and even if they were, they could not properly be said to constitute looseness.

The matter of diarrhœa is every thing that can come into the rectum, and be expelled out of it, so as to constitute liquid stools. The alimentary mass, composed of our meats and drinks, whether crude or concocted; the gastric and intestinal succus; the other juices that flow into the intestines, to wit, saliva, bile, the liquor of the pancreas, and the mucus from PEYER's glands, and other folliculi.

Besides all these, there may be blood from broken, eroded, or ~~distended~~ *dilated* vessels in the alimentary canal; pus or ichor, either from abscesses or ulcers there, or by metastasis from other parts; as from abscesses of the liver, lungs, &c.

And lastly, the general mass of blood and humors may be so fused and colligated, as to run off by the intestines through the inhaling tubuli there, and kill the person by mere inanition. This colligation may be brought on by particular diseases by way of crisis, by improper diet, by purgative medicines, or poisons.

So that the general cause, or causa proxima, as physicians speak, of diarrhœa, is the ~~inhaling~~ *influx* of thinner stuff than natural stools are made up of; which,

*influx  
into the  
rectum*

LECT. which, by it's quantity or acrimony, or both, XVIII. stimulate the rectum, so as to be expelled by the anus.

But the causes of particular diarrhœas, are almost infinite. For the enumeration of their different classes, we must refer you to practical authors.

The general indications of cure in diarrhœa are, first, the carrying off, or turning another way the matter of stools. This is done by

Vomits, which pump the matter of diarrhœa upwards, to be expelled out of the stomach; thereby preventing it from falling upon, and being accumulated in the intestinal tube. Therefore vomits, prudently administered, are one of the chief remedies of looseness. Or by

Purgatives of almost every kind: by their operation the matter of diarrhœa being drawn plentifully off, the arterial tubuli, which bring the serous humors into the bowels, are left at freedom to contract themselves, and prevent the accumulation of more. Hence, physic is most commonly succeeded by costiveness. But some cathartics leave a more remarkable astringent effect behind them than others; as rhubarb and myrobalans.

Sudorific, or diaphoretic medicines, likewise turn off the matter of diarrhœa towards the pores of the skin, and contribute towards the cure. Hence the Hippocratic maxim, *cutis raritas alvi densitas*; and vice versa.

Diuretics may likewise have some effect that way, by carrying off serum by urine, which otherwise would contribute to make up stools.

The second general indication of cure in diarrhœa, is to take away the irritation of the rectum, and it's effects. This is done, first, by carrying off the irritating matter in the way of evacuation, of which already. Secondly, by conquering acrimony, either by specific antidotes, if the particular kind of acrimony is known, as by terreous absorbent me-  
di-

didines, if it proceed from acid; by acids, if from L E C T. an alkaline putrid cause, &c. or by the general way **XVIII.** of smooth mucilaginous or oily assumpta, to blunt, and, as it were, sheath it. And thirdly, which is the most important of all, by taking away the sense and effects of irritation, while the cause remains. This is brought about by a prudent use of opiates. And therefore they are highly useful to check diarrhœas, if it were upon no other account, than to gain an immediate truce; thus preventing the farther bad consequences of the distemper, until the radical cause is levelled at, and demolished.

The last general curative indication in diarrhœas is answered by medicines, called astringent or binding. These are such, as either incrassate the animal juices, and thereby prevent or diminish their influx into the cavity of the intestines, through the inhaling vessels; or they are of such virtue, as to make these vessels contract their diameters, and shut their mouths. And not a few possess both these powers in some degree. Of the former class, ardent spirits, allum, ichthyocolla, are the chief. The materia medica furnishes great plenty and choice of the latter; as chalybeats, jesuit's-bark, rhubarb, (especially when toasted) nutmegs, plantain, tamarisc, cinnamon, tormensill, bistort, &c.

Costiveness, the opposite extream to diarrhœa, is the voiding of too hard fæces, exercised at too great intervals of time.

It is often, and indeed most commonly, occasioned by mere vigour of constitution, and strength of the concoctive powers, especially those of the intestines, by which the fæcal matter, being highly exhausted of it's fluid parts, becomes both smaller in quantity, and of harder consistence, and is therefore the longer retained, and expelled with the greater difficulty.

It



LECT. XVIII. It is prevented by a cooling, lubricating, opening diet, consisting of chocolate, fresh broths, smooth pot herbs, oil, butter, sugar, malt liquor, cyder, &c.

Moderate cathartics, such as leave the least of a costive disposition after their operation, stave off it's bad consequences for a time. When it is extreme, emollient clysters, with much oil, and a due addition of stimulating ingredients, especially those of the saline kind, repeated as occasion may require, are the most certain remedies.

Riding, and living at sea, create and increase costiveness.

Tenesmus is a continual needing, or provocation to go to stool, when no fæces can be voided. It is caused in general, by whatever creates continual uneasiness in the rectum; as external pressure from a calculus in the bladder; or from the head of the foetus at the approach of birth: these by pressing the opposite walls of the gut into contact with one another, produce the same sensation, as if there were a troublesome mass within it's cavity, and create an inclination to get rid of it. It is a frequent concomitant of diarrhoea from the acrimony of the fæces. If there is no stronger cause at the bottom, when the principal distemper is conquered, either by nature or by art, the tenesmus being but a symptom, evanishes of course. But if it continues long, and never altogether ceases, even independently on diarrhoea, though it should remarkably abate now and then, it is for the most part produced by an excoriation of the gut; which, if not healed in time, may, and often does, become a confirmed ulcer. The fæces touching the fringed or ulcerated part, ~~forced~~ of it's innermost coat, robbed of it's mucus, and acutely sensible, as all sores of that kind are, create perpetual irritation and tenesmus. This is a much more frequent distemper than is commonly imagined; and is too often

+ cured

often overlooked by practitioners, who, by treating it as a common diarrhoea, with vomits, rub and purges, and astringents, render matters much worse. The cure should be attempted by healing, balsamic, and anodyne medicines, applied chiefly in clysters; and such a diet should be directed, as is both smooth, and apt to produce the least quantity of faeces possible: as broth, eggs, the finest flour bread or puddings, jellies, &c.

Hæmorrhoids, or piles, is the distension, or varix of portions of the hæmorrhoidal veins, at the verge of the anus; sometimes external, to be seen and felt, sometimes internal, within part of the sphincter. These veins, so called from their being the seat of this distemper, answer to the artery of the same name, which is a branch of the inferior mesenteric, whose ramifications, with their corresponding veins, are distributed to the rectum, and contiguous parts. Their distension is created by faeces, in the effort of egestion, compressing the venous branches within the end of the rectum and sphincter, thereby hindering the reflux of the venous blood into the principal trunk, while the arterial canals keep constantly supplying their quota every pulsation, being more at liberty; and having their fluids propelled through them with greater force. By this means the venous twigs, exterior to the place of compression, are surcharged with blood accumulated in them, and dilated into tubercles. Hence the habitually constive are subject to hæmorrhoids. Their first appearance is commonly in straining for a hard stool: the vein, one or more, is suddenly distended into a globule, with great pain; in some days it either disappears, recovering its tone, or bursts and bleeds, which gives considerable ease. Not seldom a flux of humours being brought upon the part, permanent tumors are formed, which, by suppurating, lay the foundation of a fistula. The prevention, and, in a

LECT. XVIII. great measure, the cure of hæmorrhoids, or piles, consists in rendering the body, by a properly regulated diet, neither over costive, nor over soluble: for even looseness will bring them on, where there is a remarkable disposition that way; the frequency of efforts of egestion, though moderate, becoming equivalent to a few strong ones. To prevent great straining, where the fæces are extreme hard and dry, nothing can be done better, than to inject into the anus by a syringe an ounce or two of linseed, or sweet almond oil, a little before one attempts to go to stool.

The last disease we shall now consider, is fistula in ano. It is an abscess upon the verge of the anus, with one, or more narrow sinuses, like a pipe; whence it has it's name. Nature hath placed much fat all around the extremity of the rectum, and it's sphincter, that there may be left the greater freedom for expelling the fæces. All abscesses are formed, and all sinuses run in the tunica, or membrana adiposa, as was observed in the introductory lecture. Now, if an abscess is formed near the anus, the contained pus being in egestion pressed *quaquaversum*, will be apter to form burrows, or sinuses there, than almost any where else in the body, running this or that way, where it meets with the least resistance. These sinuses are commonly lined with callus. In order to a complete cure of the fistula in ano, every sinus should be laid open according to art, from it's beginning at the original abscess to it's termination; which being done, they are to be cleansed and healed up like common abscesses.



## LECTURE XIX.

*On the kidneys and urinary bladder. Gravel;  
calculus.*

HAVING treated last of the expulsion of the LECT. XIX.  
intestinal faeces, we come next to consider  
those organs, which separate and throw off another  
principal excrementitious matter, to wit, urine.  
The first of which is the renes or kidneys.

The kidneys are two pretty solid glandular bodies, situated in the posterior part of the cavity of the abdomen, on each side of the lumbar vertebræ, between the last false rib and the ossa iliaca. The right kidney lies under the great lobe of the liver, the left under the spleen, and therefore is higher. They are commonly about five inches long, about three broad, and one and a half thick. They are connected with the colon, duodenum, liver and spleen, by the productions of the peritonæum.

They are in shape not unlike a large bean, their circumference being convex on one side, and concave on the other. The ~~convex~~ side is turned towards the vertebræ.

*convex*

The kidneys are surrounded with a loose cellular texture, in which there is much fat. This likewise invests the renal arteries and veins. The proper coat or membrane of the kidneys is double, being composed of two laminae, betwixt which there is a very fine cellular texture; the external lamina is very thin, and only surrounds the body of the kidney; the internal one penetrates every where by numerous elongations into the substance of the kidneys, from which it cannot be separated without tearing.

The surface of the kidneys is smooth, even and uniform in adults. In the foetus, and young children, it is in a manner divided into several lobes and tubercles, almost as in the cow kind.

LECT. The kidneys are supplied with very large blood  
 XIX. vessels. The large trunks, both of the renal arteries and veins, are commonly called emulgents. The arteries arise from the aorta descendens, nearly at right angles, one large trunk for each kidney. They run horizontally to the kidneys, and commonly without division, and having sent off small branches, to the external surface of the kidney, the chief trunk enters into it's body, at it's concave part, and is distributed by an infinite number of small branches over all it's substance. The veins running along with the arteries, open in a large trunk from each kidney into the cava descendens, near that part of the aorta where the arteries arise.

If a kidney is cut quite through it's convex, towards it's concave part, into two equal portions, there appears a three-fold substance composing it's body; the exterior, or cortical part, as WINSLOW calls it, round the whole circumference of the kidney, of a bright, whitish grey colour; a middle substance, which he calls medullary, or striated, or streaked, which terminates in the third, which he calls papillary, as it ends in eleven or twelve papillæ, or nipples, from the ends of which papillæ the urine drops, as may be seen even by the naked eye, through several small holes in the cavity of the kidney.

The intimate structure of the kidney hath been found to be entirely vascular, without any follicles intervening betwixt the evanescent branches of the artery, and the minutest urinary ducts. The small arterial branches proceeding towards the papillæ, are reflected back with serpentine circumvolutions towards the surface of the kidney; then are bent again towards the papillæ; and at length send off streight urinary ducts perforating the papillæ, and tending to the cavity of the kidney called pelvis, which is continued to the ureter.

The pelvis, which is truly the head of the ureter, LECT. is the reservoir, into which the urine drops from XIX. all the urinary ducts or tubuli. It is formed by the confluence of three large urinary canals; into which the small urinary ducts open by holes laterally. This cavity, or pelvis, is straitened at length into the ureter; one to each kidney.

So that the kidney may be imagined to be a vascular congeries, consisting of arteries, uriniferous ducts, and veins, all running together over the substance of the kidney; the urinary ducts at length opening into the great urinary reservoir, or pelvis, which terminates in the ureter.

This structure hath been sufficiently ascertained by injections, which pass not difficultly from the emulgent artery into the pelvis; and therefore demonstrate that there are no follicles between the last arterial branches and the first urinary ducts.

By this apparatus is the urine separated in the substance of the kidney, and sent into the ureter. The vast largeness of the emulgent arteries, and their proximity to the heart shew, that a great quantity of blood comes in a small time to the kidneys. HALLER computes it not less than the eighth part of the whole mass. The blood that is newly come from the heart, must contain a great quantity of water, as we have found, that besides our drink, and the stomachic and intestinal juices, almost all the lymph of the body is poured upon the chyle in its receptacle in the abdomen, and duct in the thorax, immediately before it is mixed with the blood. This water, impregnated with the salts of the blood, and some animal oil, attenuated by the process of concoction and circulation, and rendered miscible with water; and united with these salts, together with subtile terrestrious parts, abraded from the insides of the animal tubes, constitute the matter of urine. The diameters of the urinary ducts are adapted to admit these, and exclude, in a sound



LECT. state, every thing grosser; as globules of blood;  
 XIX. mere oil unattenuated; milk or chyle; and serum  
 or lymph, that is concrescible by fire, urine being  
 not so. At the same time they transmit every thing  
 that is thinner, if it arrives at the kidneys; so that  
 urine is the lixivium, as it were, of the blood,  
 by the separation of which it is ~~adulterated~~; its  
 salts and oils, which begin, by repeated circu-  
 lations, to be more acrid than the tender vessels of  
 the brain and nerves could bear, being washed off,  
 and thrown out by the urinary passages.

*adulterated*

The ureters arising from the pelvis run down obliquely, and with a very small inflexion from the kidneys to the lateral parts of the inner and anterior side of the os sacrum; and passing between the rectum and bladder, are inserted in the latter. Their structure is much a-kin to that of the intestines, to wit, besides the external membrane from the peritonæum, they have an external cellular coat, under that a weak muscular one, next to that a second cellular, under that a strong nervous coat; then a third cellular; the innermost of all is smooth and membranous, and is furnished with glands, separating a mucilaginous liquor, to defend it against the sharpness of the urine. They open into the neck of the bladder, on each side, penetrating obliquely through it's coats.

The bladder is a membranous and fleshy sac or bag, capable of contraction and dilatation, situated in the lower part of the abdomen, immediately behind the joinings of the ossa pubis, and opposite to the beginning of the rectum. The figure of it is nearly a short oval; it is broader on the fore and back sides, than on the lateral parts, rounder above than below, when contracted, and broader below than above, when distended. It is conceived as divided into the body, neck, and bottom, into anterior, and posterior, and into two lateral parts, right and left. The upper part is termed it's bottom; though,

though, as we, with WINSLOW think, not with LECT. great propriety. It's neck is part of it's lower portion. The bladder is not within the cavity of the peritonæum; that membrane only covering a part of it's fundus, or upper part, and coming down no farther anteriorly, but being reflected backwards over the bladder, descends covering it, as far down as the insertion of the ureters.

The structure of the bladder is nearly the same with that of the ureters; to wit, besides the peritonæum, which covers but part of it, there is first an external cellular, under that a muscular coat, then a second cellular, then a nervous coat, and innermost of all a coat in some measure villous, furnished with glands which separate a mucilaginous liquor, here, if any where, necessary to defend it against the sharpness of the urine, which stagnates within it often, for a very considerable time together.

The fibres in the muscular coat run in all manner of directions; the outermost and most remarkable ~~se~~ is longitudinal, running from the neck upwards; and hath been thought by some anatomists to deserve a particular name, as a muscle by itself, and called detrusor urinæ; the others run obliquely by different degrees of obliquity, and some altogether transverse. The neck, or under part of the bladder, is shut by a muscular sphincter, like that of the anus.

The use of the bladder, is to receive the urine, which keeps constantly flowing from the urinary ducts and kidneys, into the pelvis and ureter; and retain it, that it may not indecently dribble, and disturb the functions of life. It seems to change it's nature, no otherwise than by it's being detained at rest in a warm place, thereby becoming more acrid and stimulating. That there are no other ways for the urine to come into the bladder, but by the ureters from the kidneys, as some authors of note

+ series

LECT. have maintained, appears plainly from experiments  
 XIX. made on live animals. When both ureters are tied,  
 the bladder never fills any more; and from mor-  
 bid cases, when calculi stop the passage through  
 both ureters, the bladder remains empty.

The urine is retained in the bladder by it's sphinc-  
 ter, till by it's distension, and the acrimony of the  
 urine, either or both, we are made uneasy, and en-  
 deavour to expel it through the urethra out of the  
 body; which is done in the same manner as the  
 fæces are thrust out; to wit, by the joint action of  
 the diaphragm, and muscles of the abdomen, as-  
 sisted by the proper muscular coat of the bladder.  
 And the pyramidal muscles, in a particular man-  
 ner, favour the evacuation of the bladder, as they  
 lie nearly over it.

There are many diseases that immediately affect  
 the urinary organs. If the urinary ducts are too  
 much relaxed or stretched, blood may be squeezed  
 through them, or chyle, or nutritive serum; the  
 latter creates what is called diabetes. They may  
 be obstructed by gritty matter called gravel; and  
 lastly, calculi are often formed in the kidneys.  
 This happens commonly, if any molecula, sup-  
 pose a small bit of coagulated blood from a ves-  
 sel broke within the kidney, is a long time de-  
 tained, either in the pelvis, or any of it's branches  
 within the kidney. Then, as the urine, even in  
 a sound state, contains a sediment of fine, chiefly  
 terrene particles; that sediment applies itself, and  
 adheres to the surface of the molecula; and the  
 united bulk gradually increases. It is not there-  
 fore absolutely necessary to the generation of calcu-  
 lus, that the blood, or other juices, should be in any  
 respect vitiated. A calculus in the bladder hath  
 been found to contain within it a needle case, which  
 had slipped up into its cavity, and there remained.

Calculi in the bladder, of such a size as to be  
 troublesome, except in such an extraordinary case



as that just now mentioned, are thought, and I believe justly, to be always at first bred in the kidneys: for if they were originally generated in the bladder, they could not, when extremely small at the beginning of their formation, miss being swept away along with the urine, and expelled through the urethra: they must therefore come from the kidneys into the bladder through the ureters, which will admit stones to pass as large as a middling olive stone, as I have often seen. Sometimes, when large, they stick in the passage, especially if they are rugged and prickly withall, for many days together, and create most violent racking pains, and bloody urine: in which piteous condition, large bleedings, oily mucilaginous medicines taken by the mouth, and thrown up in clysters, and semicupiums of warm water, are the principal remedies. In extreme violent cases, vomits, after large evacuation, have been found to do unspeakable service.

Stones slipping from the kidneys through the ureters into the bladder, increase in bulk there very much, and sometimes become so large, as to weigh <sup>many</sup> ~~several~~ ounces. By their weight and roughness, either <sup>and</sup> or both, they create violent <sup>and</sup> terrible pains, especially in making water; exulcerations of the bladder, bloody, or purulent urine, &c. To remedy which most excruciating maladies, the operation of lithotomy was practised, ~~long~~ before the time of HIPPOCRATES, ~~and is at this day~~ much improved, both in point of safety and success. <sup>but it now</sup> Methods and medicines have been lately proposed for dissolving the stone without cutting. Mrs. STEPHEN'S medicine, as it stands new modelled and amended, <sup>Dr Jurine's</sup> and a course of soap and lime-water, <sup>Lixivium;</sup> bear the highest character for that purpose: but I hesitate not to prefer the latter, as being, in my own opinion, both less dangerous to the constitution, and more effectual, than the former.

## LECTURE XX.

*Of perspiration and sweat; inhalation or respiration.*LECT.  
XX.

**H**AVING already discoursed on the evacuation of the intestinal fæces, and urine, we proceed next to consider the discharge by the surface of the body, and all those parts of it, to which the external air hath admission; to wit, perspiration and sweat. Of which, that we may have clear and rational notions, it will be necessary first to describe the structure of these two most universal integuments, the epidermis, or scarf-skin, and the cutis, or skin.

*Thick* The epidermis is a thin membrane (in most places, for in some it is ~~hard~~ and callous, as in the palms of the hand and soles of the feet) transparent, dry, scaly, of a nature approaching to horn, not capable of being dissolved by putrefaction, or maceration in water (though continued for several months) only of one fold, if considered by itself, independently on the corpus reticulare of MALPIGHIUS: If the latter is reckoned a part of it, it is then divisible into two laminæ. It is repaired after being destroyed, as appears from burnings and blisters.

The corpus reticulare is a thin membrane, closely adhering by it's outer surface to the epidermis, and by it's inner to the cutis vera; humouring all the little eminencies upon the latter, made by the nervous papillæ, roots of hair, and cutaneous glands, but in such a manner, as to remain whole, and not perforated, as MALPIGHIUS thought, and therefore called it reticular, as resembling net-work. It is softer, more mucous, and nearer the consistence of a fluid, than the epidermis, and dissolvable by maceration in water. No vessels can be shewn either in the epidermis, or corpus reticulare, by the most successful injections.

It is upon the colour of both these, but chiefly of the latter, that the complexions of the human species

ies depend. The epidermis is the more transparent L E C T.  
of the two; the corpus reticulare more coloured XX.  
and opaque. KAW, who hath most accurately examined them, says, that in a Black, the epidermis is of an ash colour; in a Mulatto lighter; and in an European white; but that it is the corpus reticulare chiefly that determines the complexion, being very black in a Negroe, and in a Mulatto tawney.

The corpus reticulare then, is probably an unorganised concretion, formed out of liquids, that transude from vessels in the surface of the skin next it, and cohering with it. The origin of the epidermis is more obscure, and authors have broached very different opinions concerning it. GARENGEOT's conjecture seems to me to be the most probable of any, to wit, that it is nothing but the external part of the corpus reticulare hardened into a crust. And if what we find in BOERHAAVE's *Prælectiones*, as published by \* HALLER, is true, to wit, that the epidermis is only repairable, when the corpus reticulare under it is not destroyed; but when that happens, an unperspirable cicatrix is formed; I say, if this is really a fact, it furnishes a strong argument in GARENGEOT's favour.

But however these things be, it is certain, that both the epidermis and corpus reticulare are perforated by innumerable pores of different sorts; to wit, those that let out the matter of perspiration and sweat; the orifices of the absorbent vessels; and the glandular emissaries, which open upon the epidermis over all the surface of the body, the palms of the hands and soles of the feet excepted: these latter furnish an unctuous matter to lubricate the epidermis, keeping it sleek, and preventing it's cracking.

The cutis, or true skin, lies immediately under the epidermis and corpus reticulare. It is made up of a close cellular texture; as a hat is wrought out of

\* See Vol. iii. p. 361. Latin edition.



LECT. beaver or rabbit's wool ; into which innumerable  
 XX. blood-vessels, both veins and arteries, and nerves  
 enter. Hence it is of most exquisite sense ; and the  
 smallest needle cannot be thrust into any part of it,  
 without fetching red blood. It's surface hath emi-  
 nences upon it, more or less numerous in different  
 places ; being chiefly the nervous papillæ, of  
 which we shall treat more particularly, when we  
 come to consider the organ of touch.

This cutis, or true skin, is found immediately  
 under the epidermis and corpus reticulare, over all  
 that part of the body, which may be called pro-  
 perly it's external surface. But in many places, to  
 which air hath access, there is no true cutis found,  
 as in the inside of the eye-lids ; the nostrils, and the  
 whole cavity of the nose ; the cavity of the mouth ;  
 the tongue ; the glans penis, and beginning of  
 the urethra in men ; and in women the inside of  
 the pudendum ; the vagina, from it's beginning to  
 the orifice of the uterus ; and the beginning of  
 the urethra : likewise, in both sexes, through the  
 whole primæ viæ, from the fauces to the anus ;  
 and through the whole aerial tract of respiration,  
 from the larynx to the membranous vessels of the  
 lungs.

But though there is no cutis, or true skin, in all  
 these places, there is the scarf-skin and corpus reti-  
 culare continued, which we must with KAW. call,  
 not the epidermis, but the epithelium : there being  
*Σηλῖα*, or papillæ there ; but not *δερμὶς*, or cutis.

Now all over the surface of the body, both where  
 there is true cutis under the cuticula, and where  
 there is not, there is a perpetual exhalation,  
 and a waste or dispendium of the liquids in the  
 body, flying off in a subtile vapour.

This exhalation, or perspiration, is called *Sancto-  
 riam*, from SANCTORIUS, a celebrated *Italian* phys-  
 ician, who flourished in the beginning of the last  
 century ; not that he was the ~~first~~ discoverer there-  
 of ;

+ Vesicles

+ first

of; but because he was the first who applied him-  
 self to the thorough examination of it's quantity  
 by statical experiments; and it's proportion to the  
 sensible evacuations; and to find out what causes  
 either promote or obstruct it; and what are the  
 consequences, good or bad, of it's increase or dimi-  
 nution.

Common sense could not but teach the bulk of  
 mankind that the body perspired. The fouling of  
 cloths without sweat; the fulying of any polished  
 piece of metal or glass by the touch, must have  
 been early demonstrations of it.

However that be, HIPPOCRATES certainly knew  
 both perspiration, and inhalation, or absorption;  
 and clearly expresses it in his usual nervous laconic  
 way, *εκπνοον και εισπνοον ολον το σωμα. expirans &*  
*inspirans universum corpus*, in the 6th section of  
 the 6th book of Epidemics; and GALEN, in his  
 Commentary, fully explains the meaning of the  
 text.

That there is a perpetual insensible exhalation  
 from the surface of the body, appears evidently  
 from a variety of phænomena. Hold a polished,  
 dry, clean, rubbed piece of metal, close (without  
 touching) to any bare part of the body, though  
 not sweating, in warm weather, and it will be  
 quickly sullied. Wipe it clean and dry, and hold  
 it again to the part, and the same effect will be  
 constantly renewed.

Fill a clear drinking glass full of cold water (if  
 sal armoniac is dissolved in it, the experiment will  
 be the more conspicuous, and satisfactory, because  
 it makes the water colder,) and hold it near the  
 bare skin, without touching it, and it's outer surface  
 will be dimmed, by the vapour exhaling from the  
 skin, being condensed by the coldness of the ex-  
 terior surface of the glass. If you put your naked  
 arm into a wide-mouthed chemical glass vessel,  
 very dry, you will soon see the internal surface of  
 the

LECT. the glass dimmed with the exhalation from the  
 XX. limb. And if it be kept long enough within the  
 glass, there will be seen streaks of moisture trickling  
 down it's sides.

And to mention only another experiment, if one weighs himself when going to bed, and again when he rises next morning, he will often be found considerably lighter, though he hath made no sensible evacuation in that time, either by urine, stool, or sweat.

From all which it is plain, that the body perspires insensibly.

Let us now inquire whence this matter of perspiration comes; and how the evacuation is made.

The cutis vera, as we have said, is supplied with blood vessels, both arteries and veins. Warm water injected into an artery, suppose the axillary artery, reaches to the external surface of the skin; and being stopped by the epidermis, whose pores are shut after death, raises it into little vesicles.

This experiment, compared with the circulation in living bodies, shews that the matter of perspiration is brought by minute arterial tubes to the surface of the skin; and flies off by pores in the epidermis; though these pores are so extremely small, as not to be seen by the help of the greatest magnifiers.

The experiment before mentioned, of the naked arm kept in the chemical glass vessel, shews that water is it's basis. But this water is more or less impregnated with animal principles, rendered volatile by the action of the animal oeconomy.—This evidently appears by hounds tracing their masters at a great distance by the scent; and even to human nostrils, people smell of their aliments; and in a particular manner, those that feed much on fish and garlic.

Those parts of the body which have no cutis, and are exposed to the air, are always moist; and



and if ever so well dried, quickly become humid L E C T. XX.  
again; therefore their perspiration is performed by the small arteries constantly pouring out their liquids upon them, which the ambient air constantly licks up, and would soon dry them quite, if there were not a perpetual supply of the same moisture.

Of this kind of perspiration, the most considerable is that by the lungs and trachea. We constantly draw in by inspiration, air as dry as it is in the ambient atmosphere; and we expel it moist, as appears by breathing upon a clean dry looking-glass, or a piece of polished metal. This perspiration from the lungs, SANCTORIUS reckons at half a pound per day. HALE estimates it considerably higher.

Insensible perspiration differs in quantity and proportion to the other evacuations, that is, to urine and stools, according to the different circumstances of the individual; in point of climate, diet, and manner of living, age, sex, and temperament.

It likewise varies in the same person in different seasons of the year, in different parts of the same day, and at different spaces of time after meals; and is different in sleep and watching.

And it is affected by exercise or rest; health or sickness; and by the passions.

In general, a warm climate, brisk exercise, if not immoderate, and beyond the strength, youth, health, and vigour, a light diet, rather moist than dry, promote and increase it.

And the contrary circumstances tend to diminish or obstruct it.

Men perspire insensibly in a general way more than women; which is owing to the greater vigour of their circulation.

And the young perspire more than the old, because the circulation in the former is brisker; the

LECT. the vessels are more yielding and permeable, and  
XX. the blood more fluid.

We perspire most after a full meal, when the digestion in the primæ viæ is nearly completed, and the blood is most turgid with new chyle, which is now attenuated enough to let it's aqueous and volatile parts fly off. Immediately after eating, while the stomach is labouring in the work of concoction, we perspire less than before; but in an hour or two we begin to perspire plentifully; and continue so doing for some hours, till the vessels begin to be empty, and the pulse sinks.

We perspire more in the warm part of the day, than in the mornings and evenings. Our pulse is raised by the increased heat of the atmosphere, and our bodies heated of course. Heat increased promotes evaporation; and by the pulse's being raised, a greater quantity of perspirable matter is brought to the exhaling vessels of the skin, in a given time.

It hath been much disputed whether we perspire most sleeping or awake. SANCTORIUS, by his experiments, makes perspiration greatest in sleep: KEILL, in his *Medicina Statica Britannica*, makes it constantly least. The truth of both the facts, as they observed them, is not to be called in question; but how are they to be reconciled? I shall deliver what occurs to myself on this head.

We shall see, when we come to consider the nature of sleep, that the circulation, during it, is slower, upon the whole, than in watching; there being no accessory stimulus to urge it on, from either the action of sensible objects, or from voluntary muscular motion; which last article is considerable even in a sedentary life. And therefore that we must perspire less in sleep, than when we are awake, *ceteris paribus*. If we sleep in our clothes, we grow colder; and if we are not accustomed to it, run a risk of catching distempers.

It

It is therefore not owing to the nature of sleep, **L E C T.** that perspiration should ever be increased; but to **XX.** our heaping bed-clothes upon us, so as to increase warmth.

The Italians, as well as the French, make supper their principal meal: but the English make their dinner their chief meal. Now, as we observed before, perspiration begins to be increased some little time after the stomach is filled; and continues to be plentiful, till the vessels become empty: so that, with **SANCTORIUS**, the time of the greatest perspiration ~~from~~ eating, coincided with the middle of the time of sleep; whereas with **KEILL**, who often mentions his going to bed supperless, and commonly sat up late, that time of the greatest perspiration arising from eating was over before his bedtime. We are likewise here to take in absorption, of which we shall say more by and by; which, *ceteris paribus*, is greatest when the air is moistest, and when the vessels are emptiest; and therefore no doubt is greater in England than in Italy; and is greater in the night than in the day-time; and greater in one, who goes to bed with an empty, than with a full stomach.

You may perhaps be curious to know in what manner **SANCTORIUS** made his static experiments. He had a chair hanging by a short beam, near the center of motion; the beam was continued to a sufficient length, marked at certain distances, in the same manner as stiliards are, by which means a small weight, at a great distance from the center of motion, might be in *æquilibrio* with, or outweigh the chair, and himself sitting in it. He knew the weight of his chair, and of his clothes; having weighed himself immediately before, and immediately after eating; he of course found the weight of all the assumpta. And weighing himself immediately before he went to stool, or made urine, he knew their weight, without the uncleanly drudgery of weighing his urine and stools. By

T

weighing

X after



**LECT.** weighing himself at different times, when he had  
**XX.** neither eat nor drank, and had been without any  
 sensible evacuation during the intervals of weighing, he found the quantity of perspiration made in these intervals.

**SANCTORIUS** deserves great commendation for the prodigious pains he took in so nicely and minutely observing, for so long a space of time, the different changes of the quantity of perspiration upon different occasions.

But is it not amazing, that in thirty years space, he should never once have thought on inhalation, or resorption from without, which is so clearly mentioned by **HIPPOCRATES**, and his commentator **GALEN**? But he seems to have taken more pains with the Arabian, than the Greek physicians. If inhalation, or resorption, is not considered, it is plain, that only the apparent, not the real quantity of perspiration can be found by statical experiments. If, for example, the body, after ten hours, is found lighter than it was by ten ounces, without any sensible discharge, it doth not follow, that just ten ounces, and no more, are exhaled during that space, because two or three ounces might have been gained in the same time by the way of resorption; in which case, the real quantity of perspiration is not ten, but twelve or thirteen ounces, so that weighing the body shews only the excess of the latter above the former, as **Dr. ARBUTHNOT** hath, and I believe the first, distinctly and explicitly taught.

**SANCTORIUS** makes insensible perspiration equal to five eight parts of the whole assumpta.

**KEILL** finds it, at a medium, rather under one half of the assumpta.

**DODART** and **GORTER**, the latter living in Holland, the former in or near Paris, make it somewhat larger than **KEILL**; but nearer the proportion he gives, than that of **SANCTORIUS**.

The use of insensible perspiration in the animal œconomy seems to be first to give vent to the oily  
 and

and saline parts of the blood and humors; which, after having undergone the effects of repeated circulation, if retained, would in time become too acrimonious, volatile, and exalted, to be consistent with that mild balsamic nature in the juices, which is necessary to keep up health, and durable life. And secondly, as these are expelled, intimately mixed with and dissolved in an aqueous vehicle, highly attenuated, and in the form of vapour, the steam, while it passes, must of course moisten and lubricate the corpus reticulare and epidermis; and likewise the nervous papillæ, preserving the latter in a fit trim for sensation.

While perspiration continues plentiful, and at the same time the body feels light and active, good health is ~~prognosticated~~, because in this state the humours must be sufficiently attenuated, to part with so many subtile and volatile parts; and all the vessels, from the largest to those that carry off the perspirable matter, which are among the smallest of all in the animal body, must continue tight and permeable; and consequently concoction, circulation, and the various secretions, must be duly carried on. But no doubt, perspiration may be too great, and weaken, by an over dissipation of our finest fluids, perhaps the spirits themselves. Obstructed perspiration, by penning up the oils and salts of the blood and juices, after they are become acrid by the action of the animal machine, is very probably a frequent cause of fevers. But KEILL's tables shew, that in our climate health doth not so critically depend upon the regularity of perspiration, as one, by reading SANCTORIUS, would be apt to believe; and that the latter may be often very much diminished, without any remarkable bad consequence. If things were otherwise, how could such a variety of business be carried on in our climate by travellers, all the hours of day and night, by land and by water, in all kinds of weather, which

LECT. XX.

*signified*

**L E C T.** so much influences perspiration, and is so variable  
**XX.** and inconstant, as not seldom to be violent in extremes within the compass of a few days, and sometimes hours? We are so made, that, while the body is in health and vigorous, the defect of one evacuation is made up by the increase of another, and things set right. Upon the whole, I am apt to believe, that too much is imputed to obstructed perspiration, in daily practice; and that the assigning of that cause is often the refuge of ignorance.

Sweat may be reckoned, and termed sensible perspiration. It comes from the same emissaries that perspiration comes from, there being no good reason to think the outlets of these two discharges to be different. Sweat is produced when the small exhaling arteries, which naturally carry off the matter of insensible perspiration, are so dilated, as to admit a sensible fluid.

Sweating, except when it is excited by labour and exercise, is always morbid, and does either harm or good, only *per accidens*, according to the state the body is in. It is a frequent way that nature takes to throw off the morbid matter in fevers, and then it is beneficial. But it not seldom proves detrimental, by diminishing the quantity of the fluids, wasting the spirits, and drying the remaining juices, by carrying off their most fluid parts.

Inhalation, or absorption, is a drawing of fluid substances into the body from without, through the pores of it's surface. This, as we have observed, was known distinctly to HIPPOCRATES: it's reality is made evident by a variety of observations and experiments. Many medicines applied to the skin, produce the same effects, as if they were taken inwardly; as mercury, cantharides, aloes, &c. By static experiments, bodies have been found heavier in the morning than they were the night before, without eating or drinking. KEILL mentions one instance, in which full eighteen ounces were gain-



gained \* ; but I wish he had been more particular L x c t.  
 about it. And in some rare cases of dropsy, urine XX.  
 hath been made in large quantities under the most  
 rigid abstinence from drink, without a detumescence of the abdomen ; which could not have happened without the absorption of humidity from the ambient atmosphere.

As the channel of perspiration and sweat is in the smallest extremities of the cutaneous arteries, opening into the air on the surface of the body ; that of absorption must be in small venous ~~tubules~~ tubuli, which, with patent orifices on the epidermis, suck up humidity from the air, as capillary tubes attract fluids, and from smaller canals, carry them into larger venous branches, and so into the great road of circulation. That this is the case, is evinced by injecting a watry fluid through a vein towards the surface of the body ; which, if there are no valves to obstruct it's course, will exude through the skin, in the same manner, as if it had been injected through an artery.

As perspiration rids the body of such fluids, as are either superfluous in quantity, or might prove noxious in quality, if retained ; absorption, on the other hand, supplies it with humidity when wanted ; and accordingly, it is greatest when the vessels are most empty, from whatever cause their emptiness proceeds. It is likewise largest when the atmosphere is most charged with aqueous contents ; and therefore, *ceteris paribus*, is more copious in the night, than in the day-time. But they concur in the other use, to wit, that of moistening the epidermis and nervous papillæ.

We shall conclude, with some reflections arising from the doctrine of perspiration and absorption, that relate to practice ; which, it is hoped, will not be altogether uninteresting.

\* Medic. Static. Britannic. Tab. 4. Decemb.

LECT.

XX. It hath been observed, in times of epidemical contagion, that a more than usually rich and high way of living, but still within the bounds of prudence and temperance, hath been found an effectual preservative. This is accounted for, by considering that high living, by keeping up the pulse, likewise keeps up perspiration; that being made through arterial outlets. But the increase of perspiration lessens absorption; whereby the chance of the deleterious effluvia, productive of the raging distemper, being introduced into the body, is diminished.

It is frequently seen, that when small-pox are stirring, those upon the spot, that are subject to a panic fear of catching them, are in a particular manner liable to be infected; and if they are, often have them in a dangerous manner. The reason is not obscure. A panic daunts the spirits, and depresses the pulse; hence a diminution of perspiration, and an increased absorption, whereby the chances of being smitten with the contagious distemper are multiplied, and a way paved for the admission of a large quantity of the baleful effluvia that produce it.

Lastly, we may conclude, from what has been said concerning absorption, that nutritive baths may be of great use, where a sufficient quantity of food, for the preservation of life, cannot be taken in by the mouth, and digested in the stomach and intestines. The value of such baths may probably be not inferior, and perhaps superior to that of nutritive glisters, as the surface of the whole body is so vastly larger than that of the inside of the rectum and colon. But I have not the least intention to disparage remedies that have been so often found beneficial; I only propose to add a new one to the number, which seems to bid fair to answer the same intention. They do not at all clash; but may be used both in the same case. The most proper

per materials for nutritive baths, are new milk, and fresh broth.

## LECTURE XXI.

*Of nutrition, growth; decrease, and natural death. Some practical conclusions relating to the different ages.*

HAVING gone through the doctrine of chyli-  
fication, and likewise treated of the excre-  
mentitious discharges of the body, method requires  
that we should next proceed to consider it's ulti-  
mate nutrition, in the smallest vessels; which will  
naturally lead us to explain animal growth, and  
decrease; and the inevitable necessity of death, ac-  
cording to the laws of nature, in this sublunary  
system.

LECT.  
XXI.

Chyle and blood can do little more than dis-  
tend the vessels they circulate in; but that is a  
small matter, ~~with respect to~~ the general nutrition  
of the body, in all it's various parts, and inmost  
recesses. Every part of the adult body is kept,  
for a considerable number of years, *in statu quo*,  
and fit to perform their respective functions, though  
they are constantly wearing, and strained. In  
what manner is this wonderful effect brought  
about!

X compared  
with

Let us first enquire, in what manner the solids  
suffer, by the actions of life, and we shall be the  
better enabled to point out the way of their repa-  
ration.

The solids suffer chiefly, two different ways, by  
the exercise of the animal functions.

First, they are elongated by the force of the heart,  
propelling blood through the conical arterial sy-  
stem. As the blood flows constantly from wider  
to narrower arteries, it meets with resistance from  
their sides, and therefore makes an effort to lengthen  
them. Hence, the ultimate arterial terminations,



**L E C T.** that open into cavities within the body, as that of  
**XXI.** the thorax, abdomen, mouth, throat, aspera arteria, and bronchia, œsophagus, stomach, intestines, all the reservoirs; as the pelvis renum, urinary bladder, &c. I say, the ultimate arterial terminations, in all such places, are constantly protruded and extended into their respective cavities. These terminations, being the smallest tubes, are likewise the tenderest, their parts cohering with the least force; for being most remote from the action of the heart, their particles have been least compacted, and consolidated, therefore they will be most easily broke off; and being but little different from fluids, in point of cohesion, will be swept away with the liquids, or vapour in these cavities, into which they begin to stand out. But such arterial tubuli as terminate on the skin, where they are exposed to the air, dry into scales, and fall off, and are regularly repaired.

By this elongation, the small vessels being distracted, their elements are pulled, in some measure, from one another, and leave interstices betwixt them, which require filling up, in order to preserve the bulk and strength of the canals.

The other way the solids suffer, is by abrasion. Fluids, constantly circulating through tubes, would in process of time wear them out, were they iron or adamant: but much sooner will soft canals be impaired; and the more so, that fluids move in them from wider into narrower diameters, which increases the friction. This abrasion is greatest in the system of arteries that carry red blood, both because the velocity of motion is there greatest, and because the red globules are the largest of any particles in the animal fluids; which therefore, especially when they arrive at the capillaries, will create most resistance, and most abrasion. In the veins it is much less, as the blood moves in them from narrow canals into wider, and with a diminished velocity, the

the veins being both more numerous, and more capacious than the arteries are. In vessels, where fluids thinner than red blood circulate, there is but little of it, as these are smoother and more fluxile, than what are contained in the sanguiferous system. But some abrasion there must be. Causes will always produce effects in proportion to their agency, be it little, or be it great.

Now it is so ordered in the animal frame, that the very causes that create the dispendium in the solids, whether by elongation or abrasion, do, almost in the same instant, or mathematical point of time, repair it. The interstices, or imperceptible hiatuses in the canals (I mean canals extremely small) occasioned by their elongation, are constantly filled up by the fluids that circulate through them; these fluids, out of which they were at first formed, to which their accretion is owing, and in which the canals to be repaired are constantly soaked. As for abrasion, if an antecedent wave, if I may so speak, wear off one or more particles, the subsequent one has particles of the very same kind in store, instantly to fill it's place; so that no physical space of time intervenes betwixt the abrasion and the reparation.

This doctrine, which is BOERHAAVE's, is greatly illustrated and confirmed by the formation of the chick, in the incubated egg. The rudiments of the chick in a fruitful egg, before incubation, appears only a sacculus, containing a clear thin liquor, or colliquamentum, the embryo itself being then invisible, even to the armed eye. In three weeks time, out of the white of the egg, gradually attenuated by the heat of incubation, so as to be taken into the inconceivably subtile vessels of the embryo, the whole chick is formed, the yolk seeming entire at the time of hatching, while the white is consumed. Out of this gelatinous liquor, con-  
a degree

LECT. a degree somewhat under that, but attenuable by  
 XXI. the heat of the incubating hen, every part of  
 the chick is formed, both solids and fluids. Now  
 the white of an egg resembles the serum of human blood in every material property; both are concrescible by the same degree of heat; both are putrescent; both are attenuable, by certain degrees of heat, under that of boiling water; both yield the same principles, when analysed chemically; to wit, water or phlegm, oil, volatile salt, and earth; and out of both, all the parts of the animal are formed; by the one, in the mother's body; by the other, within the egg. If, therefore, out of the serum, all the parts of the foetus are originally formed (except what is contributed by the semen masculinum) and grow; what wonder is it, that out of the same serum, all the waste of animal solids, in the grown animal, should be made up, and supplied *extra uterum*? The serum yields all the secretions in the body, at least, all that are not excrementitious. And the heat of our bodies produces the same effects, and brings about the same changes upon the serum, as that of the sitting hen upon the white of the egg; the degree being the same, or nearly the same; to wit, to attenuate it so highly, as to be received into the smallest vessels, and yet retain it's plastic and repairing quality.

In animals, the nearer they are to their origin, the more tender and flexible, and the more distensible are their vessels. At the same time the heart seems to be stronger, in proportion to the resistance the vessels create, in being distended and lengthened. The punctum saliens, the first appearance of the heart in the chick, beats briskly, before any of the viscera are visible. In children, the pulse is very quick, and therefore the animal grows; the vessels of every kind becoming wider, longer, and thicker. For plastic matter is not wanting, young animals  
 having



having always, if in health, voracious appetites, and quick digestions. LECT. XXI.

The cause of this greater comparative strength of the heart, seems to be it's greater irritability; muscles being more irritable, as well as nerves more sensible, in young, than in adult animals.

As the growth advances, the solids become more and more rigid, by the increase of the absolute force of the heart; though it's comparative force, with respect to the resistance it meets with in stretching them, is diminished. This increased absolute force compacts the elementary particles of the fibres more firmly together, making their cohesion stronger. And the larger arteries, by their stronger dilatations, obliterate intermediate small vessels, forcibly changing them from hollow tubes into solid fibres; which adds to the general firmness and rigidity. Hence the younger the animal is, the more vessels it hath.

But to this growth there are limits fixed. And first, the bones are stinted in their lengths by their cartilages. When the latter can be rendered no thinner and compacter by that force, which lengthens the bony fibres during the course of their growth, to wit, the action of the heart, the stature of the body, and the length of the limbs, ceases to be increased, though probably, the thickness of the bones continues to be augmented some time longer. And, by the induration of the peculiar membranes, that closely envelop their respective viscera, their bulk is likewise limited: but there is nothing to hinder a farther distension of the cellular membrane, under the skin, and in the interstices of muscles, and other places, by the accumulation of fat, so as to render the body more plump and square.

In process of time, by the incessantly repeated action of the heart and arteries, more and more vessels will be obliterated; and the coats of those, that remain

*This is a material Addition of Haller's to Boerhaave's theory*

*together with the Effects of Voluntary Muscular Motion;*

*of age approaching,*

**L E C T.** remain open, will be more indurated; sometimes  
**XXI.** so as to become ossified in particular places; the  
 { ligaments, cartilages, and bones become drier and  
 harder; the muscles, and amongst them the heart  
 itself, more tendinous, and therefore weaker, as  
 their strength consists not in their tendons, but in  
 their fleshy contractile fibres. And at length the  
 membranes, and even the cellular one itself, acquire  
 some degree of rigidity. The capillary vessels must  
 then create every day more and more resistance to  
 the heart, which is daily growing weaker. More  
 vessels will be obliterated from time to time; and  
 therefore the circulation must be performed through  
 fewer canals. The smallest canals must, in general,  
 be principally affected. Hence the organs of  
 sense are commonly first impaired, especially the  
 eye-sight, at the approach of old age. Afterwards  
 the memory and imagination suffer, and the old  
 man doats, becoming a second time a child; at  
 length, as the heart grows gradually weaker, and  
 the resistance it hath to overcome greater, it is over-  
 powered, and stops; and the blood is accumulated  
 in the right sinus, auricle, and ventricle; not find-  
 ing a way through the lungs.

This is natural death, which so few arrive at,  
 the bulk of mankind dying long before that period,  
 of some disease or other.

But there is a collateral cause of decay and death  
 in the human species, and in other animals formed  
 pretty like us with respect to the distribution of  
 chyle, not commonly taken notice of; to wit, the  
 shrinking and obliteration of the glands of the me-  
 sentery. We observed, while treating of chylifica-  
 tion, that the lacteal vessels, in their course towards  
 the receptaculum chyli, plunge in these glands, and  
 emerge again: but they are generally found, in old  
 subjects, either very much shrunk, or quite obli-  
 terated. Now, the destruction of these glands must  
 be attended with an obstruction of the passage of  
 chyle

chyle through the lacteals that enter into them. LECT. XXI.  
And if all, or the bulk of the lacteals, is thus obstructed, there must be little or no chyle sent into the blood by the thoracic duct; and consequently, the animal must be supported solely, or chiefly, by what passes into the channel of the circulation through the meseraic veins. But this falls much short of what is requisite to maintain a due plentitude of vessels, and keep up strength and spirits; and must contribute not a little towards the thinness and weakness of extreme old age, and so quicken the steps of approaching death.

From this account of things, it is plain that, in the present state of nature, no animal can be immortal, as the very actions of life tend to shorten and destroy it; and that there must be, in our species, a state of growth, and another of decrease. After the vessels and fibres are enlarged to such a degree, that they can be stretched out no farther, then every part gradually becomes drier and harder; canals are compacted into impervious fibres; the resistance to the heart becomes greater, while it's force diminishes, till at length it is disabled to continue it's vital motion.

It is observed by naturalists, that birds are more long-lived, in proportion to their bulk, than men, or quadrupeds; and that fishes are still more long-lived than birds. In the latter, it is very remarkable, that many species of them, such as we have most frequent opportunities of making observations upon, continue to grow, for ought we know to the contrary, as long as they live. Hence the enormous size of some salmon, carp, perch, pike, tench, &c. With respect to birds, I incline to believe, that the chief cause of their longevity, is their not being furnished with lacteals; by which means, one source of decay is cut off; to wit, the shrinking of the mesenteric glands, which all animals, that have lacteals, are provided with. As to fishes, the same cause



**L E C T.** cause may take place, as they likewise are without  
**XXI.** the chyliferous canals and receptacle, which the  
 human species and quadrupeds have. But there is  
 another very material peculiarity in their structure;  
 to wit, their bones are much softer than those of  
 land animals, and approach to the nature of car-  
 tilages. Hence, as LEWENHOEK justly reasons,  
 they continue much longer to be extended and en-  
 larged by the force of the heart; so that in them  
 the state of growth is scarcely limited: and the  
 cause of their natural death would appear to be ra-  
 ther the extinction of irritability in the heart, than  
 increased resistance to it's action.

We shall here, agreeably to our plan, subjoin  
 some practical reflections and conclusions, arising  
 from what hath been said.

As an animal, the nearer it is to it's origin, hath  
 the more vessels, an infant differs in it's composi-  
 tion and structure very much from an adult per-  
 son. It is, in a manner, all brain and nerves, and  
 blood and gelatinous humours, with a small pro-  
 portion of solids, the quantity of terreous parts,  
 which are the basis of fibres, being but little, if  
 compared with the watry mucilaginous humidity,  
 which cements them together. Their nerves are  
 more sensible; their muscular fibres more irritable,  
 and less tendinous, than they become afterwards in  
 the course of growth. Their bones are soft and  
 flexible like cartilages; their cartilages like mem-  
 branes, and their fat a gelly. Therefore in treating  
 the diseases of infants, the practitioner must never  
 lose sight of this difference in structure between  
 them and grown persons. Slight causes throw them  
 into convulsions; as even a moderate degree of fe-  
 ver, pains in the stomach and bowels, and almost  
 any pain of remarkable acuteness, ~~teething~~, &c.  
 Upon which account, all methods of cure, that are  
 rough and painful, should be avoided as much as  
 possible. Mercury, and mercurial preparations,  
 which

+ teething

which rash and ignorant practitioners are apt to make free with, are dangerous; if we except *Æthiops mineral*, which seems to operate chiefly, if not solely, in the *primæ viæ*. Antacid absorbents, evacuation of humours in the bowels made in the gentlest manner by *magnesia alba*, manna, *rhubarb*, well corrected; bleeding with leeches; gentle anodynes, as syrup of red poppies, and *diacodium*; mild cephalics, as *rue*, castor, and *valerian*, in small doses; are the safest and most beneficial remedies in this tender stage of life. And even these are not to be administered without great care and caution.

In youth, the absolute force of the heart is become high, but the fibres and vessels are not as yet so firmly consolidated, as they will be afterwards; therefore, in this stage, fevers, and rupture of vessels, are frequent. High living is pernicious. Heating methods and medicines are here both less requisite, and more hurtful, than in advanced years. Evacuations of almost every kind are easily born, and the waste quickly repaired.

Middle age, in a general way, can best stand the most powerful remedies of all kinds, that are duly indicated.

Old age requires an humid, nourishing and comfortable diet. Warm bathing, prudently used, is here beneficial; as it retards the increase of rigidity in the solids. Abstinence and inanition are pernicious, because a less quantity of chyle is sent into the blood, from the same quantity of ingesta, than in youth or middle age, as hath been explained. And it is probably, for the same reason, that old people, who eat plentifully, are liable to looseness, as I have often observed.

## LECTURE XXII.

*Of the senses. Of touch, taste, and smelling.*

**LECT. XXII.** **I**N our lectures on the brain and nerves, we shewed, that the brain, strictly so called, is the seat of thought, and perception of every kind; and that the nerves are the immediate instruments of sensation. And we assented to the most generally received opinion of the existence of a nervous fluid, by the flux and reflux of which, through it's proper canals, to wit, the nerves, both sensation and muscular motion are excited; the latter, by the influx of that fluid from the origin of the nerves into the muscular fibres; the former, by the reflux of the same fluid back upon it's origin, occasioned by the impulse of those bodies that excite the sensation. We now proceed to consider the different senses by themselves, as they have each of them peculiar objects, and their organs are of peculiar structures: and as the perfection and happiness of our life depends so much upon their being duly and rightly exercised. We shall follow the common division into five; and begin with the

**TOUCH.** This may be considered two ways; either as that general perception impressed on our minds, when any part of our bodies is acted upon by external palpable objects, that touch it, either by immediate contact, or mediately through folds of flexible covering, and convey the idea of pressure, pain, hardness, figure of the pressing body, &c. or it may be understood to denote that more exquisite species of it, by which we curiously examine and explore the nature and properties, as the hardness or softness, smoothness or roughness, heat and cold, figure, &c. of the bodies we touch. This sense is principally exercised by the extremities of the fingers. These species differ rather in degree, than in their natures.

We



We have before observed, that the skin, or *cutis vera*, which is of a strong, close-woven cellular texture, besides vessels, arterial and venous, and besides glandular folliculi, is plentifully supplied with nerves. See the twenty-first and twenty-third figures of EUSTACHIUS, in which the larger branches of nerves, emerging from the muscles, and going to be distributed to the skin, both on the fore and back part of the body, are delineated. These being branched out, and dispersed over every physical point of the substance of the skin, render it extremely sensible. Their ultimate filaments being collected into small bundles on the outer surface of the skin, immediately under the epidermis, form what anatomists call *papillæ*, that is, little nipples, supposed to be found over the whole surface of the skin, but much more conspicuous in some places than other; and these *papillæ* are deemed the immediate organs of touch. They are higher and more numerous in the palms of the hand, the soles of the feet, and in the toes and fingers; especially the extremities of the latter. Hence the sense of touching is there quickest and most distinct.

The perspirable matter, constantly gliding over these *papillæ*, preserves them moist, and in a fit condition to exercise their functions, as hath before been observed: and the insensible epidermis being spread over them, like a covering, and interposed between the skin and the bodies touched, prevents the sense from being too exquisite, and uneasy, or painful, as it actually becomes, when that is rubbed off.

In feeling nicely any object, in order to examine it's properties by the touch, we gently and attentively rub the points of our fingers over it; whereby the *papillæ* being affected, convey to the *sensorium commune* the idea of hardness or softness, smoothness or roughness, equality or inequality, but heat and cold, dryness and moisture, are perceived by barely touching without rubbing. It is not im-

U

pro-

LECT.  
XXII.

LECT. probable, that in nice examinations, the papillæ are  
 XXII. erected; as may be concluded by analogy, from  
 what is observed in the organ of taste. And MAL-  
 PIGHIUS imagined he actually saw that erection in  
 the papillæ of the fingers with a microscope.

Itching is a sensation occasioned by some cause gently irritating these papillæ; as perspirable matter obstructed, tickling the skin with a feather, &c. which provokes us to rub the part, and remove what is troublesome. This sensation, when excessive, is perhaps more intolerable than almost any other, and capable of bringing on universal convulsions.

Pain is caused by whatever so affects the nerves, as to endanger their destruction; whether by distraction, cutting, erosion, burning, or otherwise.

The sense of feeling in general is given us, that we may avoid what has a tendency to ruin our bodies. In particular, the acute sensation in the extremities of the fingers, enables us nicely to distinguish the different qualities of objects; thereby fitting us for mechanical purposes, in the various arts and manufactures, which contribute so much to the elegant comforts of life. It likewise serves to supply the defects of the other senses; especially those of the sight: a remarkable instance of which we had in a late celebrated professor at Cambridge. And DES PILES informs us of a blind statuary, who, by feeling curiously any face, could make a bust bearing a striking resemblance to it.

We proceed next to the sense of taste. It is only the upper part, or dorsum, and the marginal brim of the tongue, that perceives tastes. This is evinced by touching any other part within the mouth by the most sapid bodies, suppose salt; which application excites no sense of taste.

The immediate organ of taste is nervous papillæ, on these parts of the tongue we have just now mentioned, covered over with a mucous and almost transpa-

transparent membrane. These papillæ are larger and more conspicuous than any other in the body. There are found three different kinds of them; one bigger and harder than the rest, which possesses chiefly the back or upper part of the tongue. These are of a duller sensation than the other. The second are of an oval figure, lesser, and more tender than the former. They are scattered over the upper part of the tongue, and the nearer they approach to it's apex, or point, the liker they become unto the third sort, which is by far the most numerous and smallest. They are diffeminated amongst the rest, and are of a conical figure, and the most acutely sentient of all, constituting the principal part of the organ of taste; especially such of them as are at, or near the point of the tongue, where that sense is most critical.

The object of taste is, in general, of a saline nature. Water, oil, and earth, when pure, without the mixture of any salt, excite no taste at all. But, as salts are only tasted when dissolved, water serves as a vehicle to the sapid particles: oil likewise serves for the same purpose; and, besides, makes them to adhere more obstinately to the organs; thus heightening the flavour of what is tasted. Earth, by being mixed in different proportions, serves to regulate and diversify the different relishes of sapid substances.

When we are to taste, we endeavour, if the object is solid, first to comminute it by mastication: then saliva, or whatever juice the mouth affords, are poured out upon the comminuted molecula, and mixed with it. This being done, the papillæ are erected, and the thing to be tasted is pressed against the upper part of the tongue, where the papillæ are placed, by thrusting it against the roof of the mouth. The erection of the papillæ in tasting, may be seen with care and management, by the assistance of the microscope. If the tongue and mouth be quite dry,



LECT. we cannot taste at all, for want of moisture to dissolve the sapid particles.

XXII. The varieties of tastes are really infinite in number. The principal classes under which they may be ranged, are acid or sour, sweet, salt, alkaline or urinous, putrid or rancid, bitter, vinous, spirituous, aromatic or spicy, hot, cold, austere; and perhaps several others. Out of which differently combined, and mixed in different proportions, and degrees of strength, an endless diversity of tastes arises.

The sense of taste is given to excite us to eat, when our bodies require food, for the pleasure of eating; and to distinguish what is hurtful from what is salutary, by it's agreeable or disagreeable flavour. For in a general way, in sober undebauched nature, what is safely nourishing, is agreeable to our palates; and what is hurtful, disgusts us. Herbivorous animals, which have a variety of alimentary vegetables spread before them, with noxious ones intermixed, are furnished with long tongues; and therefore a larger tasting sensory; with a more exquisite structure of papillæ; which man, who may subsist upon a less variety of aliments, and is endowed with reason to enable him to profit by admonition and experience, hath not the same occasion for.

The tongue is supplied with nerves from a branch of the fifth pair.

The seat of smelling is that soft, pulpy membrane, called pituitaria, and Schneideriana from it's first accurate describer, upon which the olfactory nerves are distributed. This is the first pair, reckoning forwards, that arises from the brain. From their origin at the *corpora striata*, they pass, one on each side, under the anterior lobes of the brain, towards the *os cribriforme*; where they split into a great number of small filaments, which pass through the holes of that bone, in order to be spread

spread on the abovementioned membrane, which LECT. lines the cavity of the nose, and the sinuses that **XXII.** open into it.

These nerves are remarkably tender and soft; which tenderness, and their sudden expansion, makes it impossible to trace them far. But professor MONRO informs us, that if we break the cribriform lamella, and gently raise it, we may see the nervous filaments distributed some way on the membrane. There are no papillæ here, as on the skin, and the organ of taste; but an uniform termination; and probably the extremities of the nerves lie bare, and open into the cavities which this membrane lines.

These are, besides the nostrils, so well known, that we shall not now describe them, all the sinuses, that open into that cavity, as hath been said.

And first, the frontal sinuses are placed, one immediately above the orbit of each eye. They are pretty large cavities, formed by the separation of the laminæ of the os frontis there, separated from each other by a bony partition, and open into the upper part of the nostrils. They are never found in the foetus; and therefore seem to have been made by the action of the frontal muscles, pulling the laminæ of the os frontis asunder, while the bones are soft and yielding.

The second are the sinuses, or as some anatomists call them, the cells of the os ethmoides; which are four or five on each side, in the exterior part of the cribriform portion; like the cells of honey-combs. They likewise open by many orifices into the upper part of the nostrils.

The third are those of the os sphænoides, which are pretty large; and likewise open into the nostrils, by two orifices, one from each, into the nostrils. Sometimes, instead of two distinct sinuses, there is only one large one, opening into one nostril.

LECT. The last and largest of them all are the maxillary  
 XXII. sinuses. They are within the body of each os  
 maxillare; and open into each nostril, betwixt the  
 two ossa spongiosa.

All these are lined with the same membrane, with the fibrils of the olfactory nerves terminating in it; by which contrivance the organ of smelling is vastly enlarged.

But nature hath not thought all this fabric sufficient. There are, besides the cavities we have mentioned, two sets of bones, called *ossa spongiosa*, or *turbinata*, within the nose; one on each side. The upper are processes of the os ethmoides. They are somewhat elliptical in their circumference, pointed at each extremity, and full of inequalities and cellular recesses. The inferior *ossa spongiosa* are more independent; and rather supported by, than processes of any contiguous bones. Some anatomists, by dividing the upper into two, make three on each side. However that be, they are all lined with the common membrane of the nose, which enters into all their cellular recesses; by which means it's surface is very much enlarged.

These spongy bones are an important, if not the principal part of the olfactory organ. For it is observed, that in those animals, whose smell is acutest, the spongy bones are not only larger, but also more divided and indented; whereby the surface of the investing membrane, upon which the evanescent branches of the olfactory nerve are spread, is the more expanded.

The membrane of the nose is in general of a porous spongy texture; unequally thick in different places. Besides the nerves, that are distributed over it, and it's blood-vessels, it abounds with glands, which separate a mucous fluid, to be poured out upon it's surface; partly through cylindrical ducts, partly from round folliculi opening into it without ducts. This mucus which is formed in great plenty  
 over



over the whole surface of the membrane, serves to defend the bare nerves from the injuries of the air, and of whatever particles may float therein; and at the same time to preserve them moist, and in due trim for sensation. The lachrymæ or tears likewise contribute towards moistening the membrane, and diluting the mucus; as they constantly fall into the cavity of the nostrils from the surface of the eyes by the lachrymal ducts.

The objects of smelling are volatile effluvia floating in the air; consisting of oil and salt, highly attenuated; and intimately mixed together. The vapour of water alone is inodorous; if we sit in a new-washed room, we are not sensible of any smell, while it is drying, though the steam affects us in other respects, and not seldom produces very grievous effects. But water may, and questionless actually does serve as a vehicle to scatter abroad, as well as divide and dissolve the odorous particles: and by the oil the saline particles are more closely applied, and made as it were to adhere to the sensory.

As salt and oil blended together are the common objects of taste and smell, we may observe the analogy betwixt these two senses; with this chief difference, that in the latter they must be volatile, and float in the air; whereas in the former they may be, and commonly are fixed. Hence it is often found, that a remarkable quickness or dulness of both, go together.

It is when we draw in air into our nostrils that we smell; when we expel air, we are sensible of no odour. When we keep in our breath, we smell little or not at all. Therefore when we intend to exert that sense, nicely and curiously, we shut our mouths, and draw air repeatedly into the nose with some force. This action is termed snuffing. By it's means the odorous effluvia are forcibly applied to, and as it were detained on the sensory.

LECT. As odorous effluvia are volatile and indivisible,  
 XXII. they must be subtle and fine beyond imagination.

~ A small piece of ambergrease, or musk, retains it's odoriferous quality for years, without sensible diminution of bulk or weight. Even a paper, in which musk hath been kept, will perfume a closet for a long time together. The illustrious BOYLE hath wrote a treatise on the subtlety of effluvia.

The use of smell is in general to warn us to avoid what may prove hurtful; as there is scarce any noisome odour but what, if long continued, would become prejudicial to us in health; however they may be salutary in some morbid cases. But it's principal use seems to be to direct us in the choice of our aliments. We never venture to eat, or drink any thing we are unacquainted with, or doubt of, without smelling at it. And this we do naturally, and by instinct, without reasoning upon the matter. Upon this account most brutes are provided with a more exquisite organ of smell than man: as some of them must distinguish betwixt hurtful and salubrious vegetables, that may appear equally inviting to the eye; others must find out their prey at a distance; where their sight alone would not be a sufficient guide, &c. And they all want reason; and consequently are in a great measure debarred from being benefited either by their own experience; or that of others of the same species.

Some odorous effluvia are exhilarating and refreshing; others in some measure alimentary. There is a noted story told of DEMOCRITUS, (the greatest naturalist of his time; the shipwreck of whose works is an inexpressible loss to mankind) not unworthy of being mentioned here. He growing very old, and weary of life, determined to starve himself, and had fasted some days with that intention; but being admonished by his sister, of some public festival then at hand, which rendered it less decent  
 for

for him to die during it's celebration, than after it LECT.  
 should be over; he protracted his life three whole XXII.  
 days, by smelling of loaves of bread brought him  
 hot from the oven. I beg leave briefly to relate a  
 modern story, much of the same nature; which,  
 though it is commonly told chiefly upon the ac-  
 count of a joke in it, may yet, for aught I know,  
 contain both truth, and matter of instruction. A  
 traveller, whose finances were low, comes hungry  
 into a cook's shop, with an intention to dine;  
 while he was deliberating what victuals to make  
 choice of, that might come cheapest, he feels his  
 craving begin to abate; and stays on, till it was  
 quite satisfied with the smell of the meat, that was  
 there getting ready, in variety and plenty. At  
 length he moves off without calling for any thing.  
 He repeats visits of the same kind several times af-  
 ter. The cook, penetrating his drift, demands  
 pay of our traveller for meals he had at his shop:  
 and, upon his refusal, prosecutes him for a certain  
 sum. The judge decrees that the poor man should  
 produce the money in court, which, when the  
 plaintiff had been permitted to smell at, was to be  
 returned to the defendant; a decision no less equi-  
 table than witty. For that person must be very  
 hard hearted, who grudges a poor man the smell of  
 victuals, which, unless he had profited by it, must  
 have exhaled, and been lost.

Some odours are medicinal, and some poisonous.  
 The effluvia of wine and spirits have been found to  
 inebriate. There have been instances of aloes and  
 colocynth operating as cathartics by smell; but  
 that might be owing to imagination. The fumes  
 of kindled brimstone and charcoal, when confined  
 within a close place, prove deadly. The effluvia of  
 wine fermenting in a large cask, if directed strongly  
 through a small hole upon the lungs, are the most  
 suddenly destructive of all known poisons. Mi-  
 neral damps have often killed miners, and poisons  
have



LECT. have been conveyed with too certain effects, in the  
XXII. way of odour.

We shall say something on the diseases of the organ of smelling.

Ulcers within the nostrils, which yield purulent matter, create a constant nasty smell to the patient; especially if the spongy bones, and the other circumjacent bones, are affected with caries. This is called ozæna. The venereal lues often affects these parts. The manner of treating such cases, which often are as tedious and difficult as any that occur in surgery, is to be learned from the practice of the best surgeons; and from the best chirurgical authors.

Polypus of the nose is a fleshy excrescence of the membrana Schneideriana, which, for the most part, hath but one root, or foot, but sometimes more; from whence it's name. In the course of it's growth, it stuffs one or both nostrils (if there are two of them; which seldom is the case) and hangs down in an unseemly manner. It's root, or roots sometimes are fixed in the nostrils, sometimes in the palate; in which latter case it affects the speech, and even swallowing and respiration.

It requires extirpation, either by eroding applications, incision; or, which is generally preferred, by a ligature tied tight about the tumor, as nigh it's origin as possible. Sometimes twisting and wrenching off the roots is eligible. For the management of all which methods, consult chirurgical writers.

There is such a multiplicity of bones in or near the organ of smelling; and these of different shapes and texture; and such a variety of natural sinuses, that ulcers, fractures, caries, &c. here put on a great diversity of appearances, and require different treatment. Infomuch, that there is no part of the human body, the anatomy and physiology of which the regular surgeon ought to study more carefully,

than

than that of the nose, the cavities connected with it, and the neighbouring parts.

## LECTURE XXIII.

*Of hearing. Of sound; the ear; some diseases of the ear.*

**T**HAT air is the medium of sound, is proved LECT.  
by undoubted experiments. A bell rung in XXIII.  
open air, makes an audible sound. It does the  
same in air shut up within a receiver, and not communicating with the atmosphere. Exhaust part of the air by the air-pump, the sound of the bell will be diminished in proportion to the diminution of the quantity of the contained air; continue exhausting, and at length no sound at all will be perceived. Admit the air again; and sound will be restored, and increased according to the quantity of re-admitted air. Condense the air, by thrusting in more than makes it in equilibrio with the atmosphere, the sound will be the more heightened, the more the air is condensed.

But though sound is caused by the motion of air, it is not every kind of it's motion that produces it. The merely progressive creates it no otherwise than by the allision of it's surface upon sonorous bodies; if we except a sudden explosion, which creates a crack or report; as the bursting of an inflated bladder, or the discharge of a gun. It is the tremulous oscillatory motion of it's minute parts, their reciprocations backwards and forwards, that produce sound. This we may be satisfied of, by viewing the string of a bass violin when sounding; we can then perceive it sensibly vibrating. This vibration of the string imprints a like vibration on the ambient air, as it is compressible and elastic, it being alternately impelled one way, and restoring itself the other; thus humoring the oscillations of the tremulous chord. This tremulous motion of the air, in which we breath,  
and

LECT. and without which we cannot subsist one minute;  
 XXIII. much less exercise any sense, being propagated to  
 our organ of hearing, excites in us the idea of  
 sound.

The oscillation of the air, in order to excite sound, must be of a certain circumscribed velocity; under or above which our organs of hearing are not affected; the senses being limited. It hath been found by accurate experiments, that there must be thirty vibrations at least performed in the space of one second, before any audible sound is produced. The fewer vibrations are completed in a given time, the sound is the graver or deeper: the greater their number is, the acuter or shriller it becomes; when the number is increased to a certain degree, their effect is unperceivable by our organs; though probably other animals more minute, with nicer senses, may be affected by them. HALLER defines the most acute audible sound not to exceed 7520 vibrations in one second, no doubt upon the faith of exact experiments, and right conclusions drawn from them: which is about 250 times the number performed in the deepest or gravest audible sound. SAUVEUR in the Parisian academy, with whom MUSCHENBROEK agrees, makes the numbers of vibrations somewhat different.

We are to observe, that the graveness or deepness, and the acuteness or shrillness of sounds are qualities quite different from, and independent on their loudness or greatness; and their lowness or smallness. A deep sound may be very loud, and an acute one may be very low. Loudness depends on the force, by which the air is impelled; acuteness on the celerity of it's oscillations.

The propagation of sound is progressive, not instantaneous. It is found to move about 1050 English feet in a second; with a velocity nearly uniform. It moves somewhat slower, and not so far by much, against the wind as with it, or in a calm.

The



The density, dryness and heat of the air increase LECT.  
 it's velocity, and sphere of propagation: and the XXIII.  
 opposite qualities diminish both. }

The tremulous vibrations of the air, which create sound, affect sonorous bodies; and cause more or less the same kind of vibrations in their minute parts; as itself is agitated with. And, *vice versa*, if the minute parts of a sonorous body are first put in a tremulous motion (as those of a bell by the stroke of a hammer) they communicate the same motion to the minute particles of air.

Musicians find that some sounds agree with, or are like one another; some disagree with, or are unlike one another. Hence arise the names of concords and discords in music.

Two or more sounds are said to be in concord together, when in a very small portion of time, suppose the 100th part of a second or less, they both complete an unequal number of vibrations. If the string A performs ten vibrations in the hundred part of a second; and the string B completes five in the same precise time, then the sounds of these two strings are said to be in concord; and in the most perfect concord possible; for if they both performed the same number in the same time, they would be unisons, not concords.

Musicians divide the scale into seven natural notes, which are all distinct from one another, and have a very different effect upon the ear. When you ascend or descend to the eighth, it is the same with the first, being the most perfect concord, and called octave. And as many octaves, above or under one another, as can be expressed either by the voice or instruments, are all in concord together. But the two nearest agree more perfectly, than any two more remote. And when two notes are three or four octaves removed, they cease almost altogether to be concords.

More-

**L E C T. XXIII.** Moreover musicians find, that of the seven natural notes, the third and fifth make concords with the first; though less perfect than the octave; while the other four are discords to it.

It is a celebrated experiment, that if two strings in two violins, or any other stringed instrument, are nicely tuned, so as to be unisons, when you sound the one string, the other, without being touched, will vibrate, and create, in some degree, the same sound. The reason is, the same vibrations of air, that are excited by touching the one string, make similar vibrations in the other, which, by being tuned properly, is disposed to perform such vibrations preferably to any other. Concords likewise, though in an inferior degree, affect one another: the octave most, which is next to unison; then the fifth and third.

Sonorous bodies must be dry, hard, elastic and tense. The more they are so, the more sonorous they be.

The more tense a musical string is, it yields the acuter sound or note, its vibrations being the more circumscribed and swifter. And *vice versa*, the less bent it is, the vibrations are the slower and wider, and therefore the sound the deeper.

The shorter the string is, *ceteris paribus*, the acuter the note; and *vice versa*. Thus bass instruments must be larger than treble ones.

All this it was necessary to premise concerning the general doctrine of sound, before we come to explain the sense of hearing: to which let me add, that sound is reflected by obstacles independently on their elasticity; and that according to the same law light is; to wit, by making the angle of reflexion equal to that of incidence. And further let us observe, that what sounds we hear are not solely those made by the primary sonorous bodies, but the aggregate of all the sounds made at the same time by other ambient bodies; that are in

uni-

unison or concord with the primary sound; and LECT. likewise that addition of reflected sound, that bodies XXIII. near us furnish, when the reflexion is so very quick, as physically to coincide with the direct sound: for if there be a sensible space of time between the direct sound, and the reflected one, echo is produced. Hence sounds are stronger in a room than in the fields.

MERSENNUS in his book *De Harmonicis*, and KIRCHER in his *Musurgia* and *Phonurgia*, have treated copiously of sounds and sounding instruments. Writers on experimental philosophy, the chief of which are s'GRAVESANDE, DESAGULIERS, and MUSCHENBROEK, likewise handle this subject. HELSHAM'S lectures are an excellent epitome; and SCHELLAMER *de Auditui* contains almost what is sufficient of this doctrine, as far as an account of the organ of hearing is concerned.

We now proceed to consider the organ itself. It may be divided into the external and internal: the external are those parts, which appear outwardly without dissection; to wit, the ear properly so called, and the external auditory meatus or passage.

The ear is formed of a pretty thick cartilage, covered with a close cellular texture, without fat, (except in the lobe, where the cartilage breaks off) and with the *cutis vera*, and epidermis above all. The cartilage, and it's integuments, are folded into circumvolutions, in some measure spiral, which lead to, and terminate in the entry of the meatus or passage. The use of the ear is to gather, like a funnel, and determine the tremulous air into the meatus. Hence those who have lost their ears, hear not so acutely as others; and endeavour to supply that want by applying the palm of their hand made hollow to their ears. Hence the usefulness of hearing-trumpets. Quadrupeds, especially the most timorous of them, as deer and hares,



**L E C T.** turn their ears, by muscles furnished for that purpose, towards the place, from which noise proceeds, that they may hear the more acutely.

As there are two ears, right and left, both on the outside of the head; by the help of turning about the head, sounds, from whatever quarter they may come, are gathered by either or both, with the greatest advantage.

The muscles of the external ear in human subjects, are but a few cutaneous fleshy fibres, the action and use of which is obscure and inconsiderable. They may serve in some measure to dilate or contract the entry into the meatus, as sounds are weak or strong; which is **DUVERNEY**'s opinion: or, according to **HALLER**, by their action they may make the ear tense and steady, when we have a mind to hear most distinctly. In brutes, whose ears have a manifest motion, they are stronger and more conspicuous.

The meatus or passage of the ear leads to, and terminates in the membrana tympani, or drum of the ear. It is partly cartilaginous, and partly bony. The former is a continuation of the cartilage of the ear become narrower. It is broken and interrupted in three places, which are joined only by the skin, which lines it's inside. This skin, with an epidermis covering it, is spread over with a vast number of glands, to secrete that fluid, which, when thickened by being long enough exposed to the air, is the wax of the ear; this is not only a natural balsam or liniment to keep warm and moist the acutely sentient skin of the meatus; but moreover serves to entangle dust or small insects flying in the air, that might prove hurtful to the membrana tympani. When this wax is accumulated in too great quantity, it obstructs the meatus, and creates the most common kind of deafness; the remedy of which is picking the ears, or syringing them. There are likewise hairs, which

which grow in the inside of the passage of the ear; LECT. the use of which seems to be to create an itching or tickling there, when the meatus is foul, in order to prompt us to pick, and clean it. XXXIII.

The bony part of the meatus is continued to the cartilaginous; and terminates at the *membrana tympani*. It is as it were an addition to the temporal bone.

The meatus, thus composed of cartilage and bone, and thus covered or lined, is not streight, but crooked and winding, to defend the *membrana tympani* against the force of excessive sounds, and other injuries.

At the extremity of this meatus is the *membrana tympani*; which is stretched upon the bony part, all round: and so forms a close partition between the external parts of the organ of hearing and the internal. This is an oval membrane; thin, dry, firm, and transparent. Though it seems stretched pretty tight, yet it is not plain, but concave outwardly, and inwardly convex; being pulled that way by the handle of the malleus, which is fastened to it.

Under this membrane, or rather within it, is the cavity of the tympanum; in which are the three principal *ossicula auditus*, with the fourth and smallest. The first is called the *malleus*, or hammer, from it's shape. It's handle, as we have said, is fastened to the *membrana tympani*; it's head to the body of the second bone, called *incus* or anvil. The long leg of the incus is articulated with the *stapes* or stirrup; and in this articulation is placed the fourth and smallest bone, called from it's figure *orbiculare*. See DUVERNEY, Fig. V. The basis of the stirrup is fixed to, and covers all the entry of the *foramen ovale*, of which more by and by.

The malleus is furnished with muscles, concerning the number of which anatomists disagree; some, among which is the most accurate ALBINUS, reckoning

LECT. reckoning three ; others only two, and denying XXIII. the existence of that called by ALBINUS *laxator tympani*. HALLER declares he never could find it. The other two muscles of the malleus are acknowledged on both sides. The one bends the tympanum, by pulling it inwards and rendring it more concave, as it is inserted in the handle of the malleus, which is fixed to the inner and convex side of the tympanum. The other, according to HALLER, when acting, draws the malleus from the inens ; in some measure interrupting the propagation of tremors from the one bone to the other.

The *stapes* or stirrup hath a peculiar muscle to itself, which serves for the tension of the membrane, by which it's basis is fastened to the *foramen ovale* ; and, as DUVERNEY, not improbably, conjectures, to add to the tension of the bony fibres of it's proper structure.

These little bones of the ear, and in general the whole bony proper part of the organ of hearing, are remarkably hard and flinty ; even so early, as in the ripe foetus. But they are not devoid of periosseum, as DUVERNEY pronounces. RHUYSCH, by his injections, hath demonstrated vessels on their surface ; which must be supported by a membrane, as they are every where else in the body.

Besides these bones, there are in the cavity of the tympanum four holes, leading to what is called the labyrinth. The first is the *foramen ovale*, or *fenestra ovalis* ; to which, as hath been said, the base of the stapes is fixed, and compleatly stops it. This leads to the *vestibulum*, into which the three semicircular canals open. The second, called *foramen rotundum*, or *fenestra rotunda*, leads to the *cochlea*. The third to the *tuba Eustachiana*. The fourth into the cavity of the mastoid process.

The three semicircular canals open into the vestibulum by five orifices ; as two of them join together, and make but one opening at one of their extremities.



extremities. They are like so many passages dug out in a piece of ivory. Their diameters are unequal, not only if the whole cavity of one canal be compared with that of another; but likewise in different parts of one and the same canal. LECT. XXIII.

The *coclea* is a spiral bony cavity, resembling the winding of the shell of a snail, whence it hath its name. It is formed by a bony canal, or rather groove, rolled spirally from bottom to top round a bony spindle, tapering to an apex or point, like the fusee of a watch; making in all two turns and a half. This canal is divided, all it's length, into two, by a bony lamina fastened to the bottom of the canal. This lamina follows the canal in all it's windings; and becoming gradually narrower, as it approaches to the apex, terminates in a very acute angle; thus leaving two openings in the extremity of the canal, one on each side; which lead to the vestibulum, and *foramen rotundum* respectively.

The *tuba Eustachiana*, to which the third foramen leads, so called from it's first accurate describer EUSTACHIUS, is a canal, one on each side, by which the air we breath finds admission from the palate, or fauces, into the cavity of the tympanum. This tube, by DÜVERNEY improperly called aqueduct, begins membranous, opening into the back part of the nostrils, above the uvula. In its progress towards the internal ear, it becomes partly cartilaginous, and at length bony; in that state opening into, and communicating with the cavity of the tympanum.

As the mastoid process, to which the fourth foramen leads, seems to be no proper part of the organ of hearing, we forbear any farther mention of it here.

The organ of hearing is supplied with nerves from the seventh pair, called the auditory. They arise, one on each side, from the great transverse protuberance of the medulla oblongata. Each of

LECT. these nerves is double, consisting of two ropes, XXIII. one of which is small, and solid; and therefore called the *portio dura*; the other larger, and softer, called the *portio mollis*. It is this latter that is chiefly, and indeed almost solely distributed to the organ of hearing; and therefore is properly the auditory nerve.

These two portions run together till they come to the end of a pretty large sinus in the *os petrosum*, called *meatus auditorius internus*. There they separate; the *portio mollis* immediately dividing into small filaments, and piercing through the *os petrosum* by different small holes; and distributing itself, soft and pulpy, on the periosteum of the inside of the semicircular canals; of the cochlea, and the vestibulum.

The organ of hearing is supplied with blood vessels from branches of the carotids and vertebals.

Though there is much obscurity in tracing the uses of so operose a machinery, as that of the ear is; and though we must despair of ever finding out the particular design of nature in most of her *minutiae*; yet I apprehend enough may be gathered from the nature and phænomena of sounds; from the evident structure of the parts; and from the analogy of musical instruments, to form a general idea of the functions of this organ, almost sufficient to satisfy the wise philosopher; and to direct such practical methods in the art of healing, as it is in our power to apply. I shall briefly sum up what I take to be the substance of this doctrine.

First the waves of the tremulous air being collected by the external ear, in the manner we have said, and conducted through the winding external passage, strike the *membrana tympani*. This membrane being stretched remarkably tight upon the bony brim of the tympanum, and being very dry and hard, and therefore elastic, is thereby excited  
into

into like tremors. It's tension is regulated by the two muscles of the malleus, which either bend or relax it, as occasion requires; the latter when the sound is over violent; the former when it is faint, and not easily audible without accurate attention. The tremors of the *membrana tympani* are communicated to the bone it is stretched over, and the bones contiguous to it; and likewise to the malleus, the handle of which is closely fastened to it, by almost all it's length. The malleus transmits them to the incus, with which it is articulated; the head of the former being received by a depression in the body of the latter. The incus propagates them to the stapes, with which it is joined; and the fourth small bone at their junction renders their propagation more perfect than it would be, if the articulation were wholly ligamentous. But the incus likewise communicates it's tremors to the bony part or barrel of the tympanum, as it is attached to it by it's short handle. The stapes, regulated by it's muscle, as it is fixed to the *foramen ovale*, transmits it's tremors to the whole labyrinth; but most directly to the vestibulum, and semicircular canals.

These small bones, therefore, not only serve to bend or relax the *membrana tympani*, but likewise to propagate it's tremors to the internal ear, in some measure like the sound-post of a violin; by which I understand that piece of stick running transversely in it's inside, from the middle of it's belly, to the middle of it's back; whereby the tremors excited by the vibration of the strings in the belly, are communicated directly to the opposite plank, or the back. If this stick be taken out, the sound of the violin will be much impaired. But nature here, as every where else, is infinitely superior to art: for in a violin the sound-post remains in the same state of tension, as long as the instrument is tuned to the same pitch; whereas the bones of the

*dele s.*



LECT. ear are stretched more or less in an instant of time,  
 XXIII. as different occasions require, by the action of their  
 muscles.

As the principal and direct termination of the influence of the *ossicula auditus* is upon the vestibulum and semicircular canals, it is natural to conclude that this is the principal part of the organ of hearing: and the more so, that, as DUVERNEY remarks, birds want the cochlea; some of which, at least, hear very exquisitely; for example, song birds; otherwise they could not warble so sweetly. The semicircular canals, being dug out in the hard elastic *os petrosum*, in a semicircular form, and compleating rather more than half a circle, must of course cut the bony fibres into infinite intermediate degrees of lengths, from the longest to the shortest; that so in every degree of gravity or acuteness of sounds, within the limits of our perception, there may be an infinity of fibres in concord or unison with the original sound; and affect the soft auditory nerve, spread upon their periosteum accordingly. Analogous to this contrivance of nature, but much inferior in ingenuity, are the two ~~inverted~~ S's in the belly of violins; and the holes in wind instruments, by which the wood, or whatever other matter they are made of, is cut into fibres, differing from one another in length, by indefinitely small degrees.

No doubt the cochlea contributes a large share towards the sense of hearing; and renders it more perfect and critical. Nature, which does nothing in vain, would not have been so profuse in a wonderful structure here, without answering a suitable purpose. It's winding canals occasions a minute division of bony fibres into different lengths, to be in consonance with different sounds. And the like division is not a little increased by the spiral lamina; which being a long, very acuteangled triangle,

angle, exhibits the nicest imaginable divisions of the bony fibres of it's structure. Whence, if we suppose the periosteum of all the inside of the cochlea to be spread over with pulpy expansions of the auditory nerve, it may be concluded the same effect is here produced as in the semicircular canals: to wit, a communication of infinite different degrees, or intervals of tremor to the sentient principle.

The *tuba Eustachiana* supplies air to the cavity of the tympanum, as the external meatus does to the outsides of it's membrane; but in less quantity and less directly; and by this means, it is transmitted warm, and moist with the animal vapours it acquires in it's passage; that it may not dry and cool too much the delicate periosteum of the small bones, and cavity of the tympanum. Air from this quarter is necessary, that there may be an elastic fluid to assist, and co-operate with the tremors of the *membrana tympani*; and likewise to increase the auditory faculty, by adding another avenue to the organ. Hence some people hear best when the sound is directed into their mouths.

From what hath been said, we may, it is hoped, fairly conclude that hearing is a sensation excited in the mind immediately by impressions made upon the ultimate expansions of the auditory nerve, within the cavities of the semicircular canals and cochlea; and mediately by sound affecting the whole organ of hearing, so as to create such tremors in it's bony and elastic parts, as may cause these impressions; the *membrana tympani*, the small bones of the ear, with their muscles; and the rest of the bony structure, being only an apparatus for that principal purpose.

DUVERNEY is by much the best, and indeed the classic author upon the ear. If to him VALSALVA and CASSEBOHM are added, the student will have almost every thing requisite for his information.

LECT. HALLER in his *Primæ Lineæ*, is chaste and correct XXIII. with respect to the physiological part; drawing no conclusions but what are justified by the structure of the parts.

We shall here add something briefly concerning the most frequent diseases of the ear; referring the student for the rest to DUVERNEY; who, in his third part concerning the organ of hearing, has treated of them in a most excellent manner; and admirably illustrated the connexion between rational practice, and a knowledge of the structure and functions of the parts affected.

As hath been already hinted, the most common cause of deafness is an accumulation of wax in the external passage; the remedy is dislodging it, by picking or syringing the ear. But as the wax is sometimes hard, and even stony, it is in that case necessary previously to drop into the ear some drops of oil of bitter almonds, quickened with a small proportion of the chemical oil of anise seeds or amber, directing the patient to sleep lying upon the opposite side; and afterwards proceed to syringing. The proper liquor to inject is soap suds, with some tincture of myrrh, or traumatic balsam, made milk warm, or somewhat warmer. The injection is to be pushed in gently, not to violate the membrana tympani.

But in all complaints of deafness, the practitioner ought carefully to examine the state of the ear; and learn whether the patient has, or hath had any abscess in the external meatus of the ear affected, that might have eroded the membrane of the tympanum; and he should try whether it is sound or not. This is done by holding a lighted candle to the affected ear. And if upon a strong effort of expiration determined towards the ears, by stopping the mouth and nostrils, the flame of the candle is sensibly acted upon, we may conclude the membrane of the tympanum to be broken; and the



the hearing by that ear irrecoverably lost. For the LECT.  
cold air gets directly through the breach into the XXIII.  
cavity of the tympanum; and by chilling and dry-  
ing the delicate periosteum of the little bones, and  
the membranes of the cavity; and the small mus-  
cles, renders the parts unfit for performing their  
functions.

If the membrane of the tympanum be sound, the prognostic is more favourable. But even then, we seldom can ascertain the particular cause of the deafness: and if we could, we should be at a loss how to apply the remedy indicated; as we cannot get into the inward ear, there is little to be effectually done towards a cure, besides dropping comfortable things, of the oily and balsamic kind, into the external meatus; and keeping it warm by plugging it with soft wool or cotton. Attenuating, and aperient cephalics, with gentle mercurial and antimonial preparations, may be tried inwardly.

If there is an abscess in the external meatus, it ought to be healed as soon as possible; that the pus may not at length affect the tympanum.

Inflammation in any part of the organ of hearing, is to be treated as other inflammations.

## LECTURE XXIV.

*Of light; of the eye, and vision.*

**B**EFORE we enter upon a detail of the struc- LECT.  
ture of the eye, and the uses of it's parts, it XXIV.  
will be necessary to premise as much concerning the  
nature and properties of light, as is requisite to  
make what we shall have occasion to deliver upon  
that subject, understood.

Light is an emanation from lucid bodies. That it is corporeal, sufficiently appears from it's affecting our sense: and the reasoning of LUCRETIVS,  
to

LECT. to prove that sound is body, holds equally good to  
XXIV. evince that light is so;

*Tangere enim et tangi, nisi corpus, nulla potest res.*

A lucid body is seen by an eye placed at a proper distance any where around it, if no opaque bodies are interposed; and not only the whole surface or general figure is seen, but the several parts are in some measure distinguished: and therefore optical writers have, with good reason, laid it down as a maxim, that from every point of a lucid body an infinite number of rays of light run in streight lines all around it; which, the farther they proceed, must of course spread the more, receding from one another, in proportion to their progress: This, in the language of optics, is called diverging.

The propagation of light, is not, mathematically speaking, instantaneous; for the observations of M. ROEMER and Dr. BRADLEY, prove that it takes up seven or eight minutes in passing from the sun to the earth: however, with regard to all sublunary phænomena, it's propagation may, without error, be considered as instantaneous.

When I say that rays of light proceed in streight lines *quaquaversum* from every point of a luminous body, I suppose the medium, through which it passed, to continue the same. If the lucid body be placed in air, for example, that the medium is air continued; if in water, that the medium is water continued, &c. and I particularly except the interposition of opaque bodies.

Light then may meet with two sorts of interruption of it's direct course. The one from the obstacle of opaque bodies, which either reflect, that is, turn it another way, or smother and destroy it. The other from a change of the transparent medium; which, though it transmits it, yet it causes it to alter it's direction at it's entry into the different

rent medium. This change of the course of light, LECT.  
 arising from the diversity of medium, is called it's XXIV.  
 refraction; as the rays are as it were broken this or  
 that way, like a stick snapped in it's middle, the  
 fragments still cohering, but not preserving streight-  
 ness.

It is found, by experience that rays of light falling upon the plain surface of polished opaque bodies, are reflected in such a manner, as to make the angle of their reflexion equal to that of their incidence: and that in refraction, the sine of the refracted angle, bears a constant ratio or proportion to the sine of that of incidence. The former law is the foundation of catoptrics, or the doctrine of reflected light; the latter of dioptrics, or the doctrine of refracted light.

It is likewise found, that some transparent mediums refract the rays of light more than others. And as, generally, the denser the medium is, that is, the greater quantity of matter it contains under the same magnitude; or, which is the same, the heavier it is specifically, the more it turns the incident ray out of it's direct course, or refracts it the more; therefore, in optics, the more refracting medium is commonly called, for shortness sake, the denser; and the less refracting one the rarer medium. I say, generally, because some few mediums refract more strongly in proportion to their density, or weight, than others. Thus rectified spirit of wine, and oil of turpentine, refract more than water, though the water is heavier than either. But, setting inflammable mediums aside, the rule I have mentioned holds universally. Thus water refracts more than air; and glass more than water: gems refract more than glass; and the diamond most of all, as it is the heaviest, as well as the hardest, of all known transparent bodies.

I shall mention such of the principal propositions demonstrated in dioptrics to flow from the above-mentioned



LECT. mentioned fundamental one, as are necessary to be  
 XXIV. known, in order to make the mechanism of the eye,  
 and the uses of it's parts, understood.

And first, rays passing out of one medium into another of different density, if the mediums are joined by plain surfaces, after refraction, are neither more collected nor more scattered than they were before incidence. If they were parallel, they continue on so; if diverging or converging, they proceed in the same tenor, without altering their course.

Secondly, rays coming out of a rarer medium into a denser, if the surface of the denser medium be convex, they become more converging than before. And the denser the medium is, and the more convex it's surface, they are rendered the more converging.

But if they pass from a denser medium into a rarer, falling upon a convex surface of the latter they will become more divergent, than they were at the place of incidence.

And if they pass from a denser medium, and fall upon the concave surface of a rarer, they will become more convergent than before.

Hence a lens with two convex surfaces, will make rays falling upon it more converging than a lens with one convex and another plain surface; the convexity being supposed the same; after emerging from it into air.

And a meniscus with two concave surfaces, will scatter rays falling upon it more than a glass with only one concave surface, and the other plain, the concavity being equal in both.

These are the principal propositions demonstrated in dioptrics, which must be kept in sight when we come to treat of refraction by the humours of the eye.

The ancients were probably as well acquainted as we are with optical matters, as far as the different

rent.

rent refrangibility of the rays of light is not con-  
cerned. And it would appear ARCHIMEDES un-  
derstood the effects of speculums better than the  
moderns. He wrote on that subject a very large  
volume, according to the testimony of APULIUS,  
which is lost. And it is but very lately that the  
ingenious Mr. BUFFON hath revived the manner of  
burning at a large distance with plain speculums  
properly disposed, which the great ancient put in  
practise against the Roman ships, at the siege of  
Syracuse.

But it was reserved to the immortal NEWTON to  
discover the different refrangibility of the rays of  
light, and the true doctrine of colours. He, by  
 dint of experiments, and a sagacity and penetration,  
both in the manner of contriving them, and in  
drawing conclusions from phænomena in the chastest  
and most ingenious manner, hitherto unequalled:  
I say, he found out that each ray of light consists  
of seven different ones, joined together in one bun-  
dle, or rather pencil; all which have different de-  
grees of refraction; the red ray the least of all:  
next in order the orange, yellow, green, blue, in-  
digo and violet. This last is the most refrangible  
of any; the other are the less refrangible, as they  
are nearer to the red in the order I have placed  
them: that the sun beams, and whiteness, are an  
uniform mixture of all these: that black, like  
shade, is a privation of colour, where few or no  
rays are reflected; they being smothered and de-  
stroyed: that the other colours are formed by these  
rays, which constitute the abovementioned origi-  
nal colours respectively, their being reflected co-  
piously by the coloured bodies, while the bulk of  
the rest is scattered irregularly, or suffocated and  
lost. This doctrine, with many other particular  
properties of light, Sir ISAAC spent thirty years in  
discovering and confirming. And though it met  
with all the opposition, that envy and malice could  
muster

LECT. mustler up against shining merit, for a great part of  
 XXIV. his own life time; and is still nibbled at by our  
 neighbours the French; (though, to say the truth,  
 it was early patronised in that kingdom, by the ingenious  
 father PARDIES and since by cardinal POLIGNAC) yet being founded upon a solid basis,  
 to wit, experiments, it still maintains it's ground,  
 and is like to stand as long as ingenuity and arts  
 subsist amongst mankind.

An infinite number of books have been written on optics. For the beginner, GREGORY's Elements of catoptrics and dioptrics, with Sir ISAAC NEWTON's Optics, may be sufficient. HELSHAM in his Lectures, treats excellently on optical matters. And Dr. SMITH hath, not many years ago, published a full system in two quarto volumes.

It is now time to come to the description of the structure of the eye; and it's functions.

And first let us observe the supercilia, or the eye-brows, an arch of hair above each eye; which when pulled down by the corrugator muscle, and the *orbicularis palpebrarum*, makes a kind of shade, to preserve the eyes from the violence of excessive light. It likewise serves to entangle dust and insects, and turn off sweat from running down the forehead upon the eye. They add grace and dignity to the countenance, and diversify faces, and contribute principally to express the passions, as is well known to painters. They are pulled upwards by the frontal muscle.

Next, the eye-lids serve to open and shut the eye. Their margin is faced with a cartilaginous arch, which makes them shut the more completely, by hindering them from running into folds. In this arch are planted the cilia, or eye-lashes, which are stiff hairs, that keep off dust, regulate the quantity of light, and add very much to the beauty of the face; they likewise diversify countenances, by their different lengths, as well as colour.

That



That the eye-lids may move the more glibly, **L E C T. XXIV.** and without pain, their insides are furnished with sebaceous glands, called *Meibomianæ*, from *Meibom*, a learned German physician their describer. They open by about thirty or more holes in the margin of the eye-lids: they separate an oily or wax-like substance; which, together with the lachrymæ or tears, serves to moisten and lubricate both the inside of the eye-lids, and the eye itself, and facilitate their motions. The inside of the eye-lids are plentifully stored with large blood vessels, covered over with a thin smooth membrane, by which means the eye is kept constantly warm.

The lachrymæ or tears, is a limpid, thin, saltish, evaporable fluid; which is supplied by the mouths of small arterial ducts, opening upon the surface of the *tunica conjunctiva*, that thin external covering of the fore part of the globe of the eye, which joins the eye-lids to the eye; of which more anon. And according to several writers, they are likewise furnished by a gland or gland-like substance, called the lachrymal gland, situated in the outer angle of each eye. In cows several ducts are found coming from this gland; and opening into the inside of the palpebræ: but as some of the ablest, and most curious anatomists of this age, have not been able to find them in the human subject; that source of tears is justly called in question.† This fluid is constantly supplied, and serves to keep the fore part of the eye, where the cornea is moist, smooth, clear and shining; as well for the easiness and quickness of motion, as for the purposes of vision. What of it is superfluous, partly exhales in the air, and partly is taken up by the *puncta lachrymalia*, which are two in each eye, at it's inner angle, and the conjunction of the eye-lids, and thence sent to the lachrymal sac, to be drained into the nose. When these puncta are stopped or obstructed any how,

+ Dr Monro  
junior hath  
very lately  
discovered and  
described se-  
veral Lachry-  
mal ducts in the  
human sub-  
ject.

LECT. how, the tears trickle down the cheeks, and sometimes XXIV. times gall and excoriate them.

For the motion of the eye-lids, there is a muscle called *elevator palpebræ superioris*, which rises within the orbit, and is inserted in the margin of the upper eye-lid; and the *orbicularis* or *sphincter palpebrarum*, which shuts the eye-lids; and therefore pulls down the upper eye-lid, and draws up the lower one. Winking and twinkling of the eye-lids are partial, alternate contractions of these muscles; partly voluntary, and partly involuntary; the latter occasioned by the irritation of the salt lachrymæ; which motion is constantly, at small distances of time, repeated, almost without our being conscious of it; by which the eye is preserved smooth and clear.

At the conjunction of the eye-lids at the nose, which is called the great angle of the eye, is placed the *caruncula lachrymalis*. This is a congeries of glandular *folliculi*, where an oily substance is separated; and serves as a supplement to those of Meibom's glands; which leave off there. There are likewise little hairs observed in it; ~~the~~ considerable use of this caruncula is to arrest and retain extraneous things, that may get into the eye; such things never cease irritating the eye, till by the repeated action of the orbicularis muscle, and by the assistance of lachrymæ being squeezed out plentifully to set them afloat, the irritating particles are shoved towards this caruncle; where, by the viscosity of the secretion, and the hairs, it is entangled; and retained with less uneasiness, till it may be taken out.

The eye itself is a globe or sphere, lodged in a bony cavity, made up of part of seven bones, as is shewn in osteology, called it's orbit, of a conical figure, tapering backwards, and spreading wide anteriorly; much larger than the eye it contains, the interstices between the eye and it being filled up chiefly with fat, to make it moveable every way; and

and the muscles which cause it's motions. The LECT. bulk of the eye is made up of coats or membranes XXIV. and humors; besides vessels and nerves.

The coats, or membranes of the eye may, with WINSLOW, be divided into three kinds. Some form chiefly the globe of the eye. Some are additional, being fixed only to a part of the globe; and some are capsular, which contain the humors.

The coats, which form the globe of the eye, are three; the external is the sclerotica or cornea, so called upon the account of it's hardness; though the name cornea is by custom ~~conferred~~ to express it's anterior transparent part; the middle is named choroides; and the third and innermost is the retina.

+ confirmed

The additional coats are the albuginea, which form the white of the eye; and the conjunctiva, or adnata.

The capsular coats are likewise two: the vitrea, that which incloses the vitreous humor; and the chrySTALLINA, that which envelops the chrySTALLINE humor.

We shall first describe the additional coats, because they are most external; then proceed to the principal coats, and reserve the description of the capsular, till we come to talk of the humors.

The *tunica conjunctiva*, or *adnata*, is a continuation of the same thin membrane, that lines the inside of the eye-lids. It covers all the anterior part of the globe, that can be seen by pulling open the eye-lids; and immediately joins the ball of the eye to the eye-lids, whence it hath it's name. It is very full of capillary vessels, which in an ophthalmia or inflammation of the eye, admit red blood, and appear turgid.

This coat hath under it a thin cellular texture, by which it is connected to the albuginea. This is what makes the white of the eye, as I have already said; and appears on all the anterior convex part of



**LECT.** the globe, from the transparent cornea to the beginning of the posterior side. It is formed by the  
**XXIV.** tendinous expansion of the proper muscles of the eye; and chiefly of the four recti. It adheres closely to the sclerotica, which makes it opake and white; appearing so through the transparent conjunctiva above it.

The sclerotica is the most external, the thickest and strongest coat of the eye; and invests the eye all round, except where the optic nerve enters; and by it's figure and solidity, chiefly renders the eye globose or spherical. It is judged to be the continuation and expansion of the dura mater, which invests the optic nerve, before it enters the globe of the eye. The greatest part of it is opake; but it's fore part is transparent, and, as I have said, commonly is called cornea simply. This transparent part or cornea is somewhat more convex than the opake part; so that it represents the segment of a smaller sphere, added to the segment of a greater. This difference is not equally great in all persons; as we shall have occasion to take notice hereafter. The cornea is perforated by a great number of imperceptible pores, through which a very fine transparent liquor is continually discharged, and soon exhales; which may be perceived by pressing the eye in a subject, soon after death, having first wiped it clean; for we see then a gradual collection of a very subtile liquor, which coalesces into drops. It is this dew which forms a pellicle or glazing on the eyes of dying persons, which sometimes cracks soon after death. See Memoirs of the Academy of Paris for the year 1721.

The second coat of the globe of the eye is called the choroides. It is blackish, or of a dusky brown colour, more or less inclining to red. It adheres close to all the opake part of the sclerotic, and at the junction of the transparent part with the opake, it recedes from it, and leaves it to form a septum,  
 or

or partition, which divides the lesser segment of the sphere, the surface of which is the cornea, from the larger segment whose surface is the opake sclerötica. LECT. XXIV.

In the middle of this septum there is an hole called the pupilla. The anterior and exterior part of this perforated septum is called the iris, because in different persons it is of different colours; hence the denomination of grey, blue, brown, hasel, black eyes, &c. The posterior or internal part of the septum is black, and is called the uvea.

According to WINSLOW, and many other anatomists, between the two laminæ of this septum (for the whole choroides consists of two laminæ, which may be separated by maceration) there are placed two planes of true muscular fibres, the one longitudinal and radiated, running from the exterior margin of the septum, towards the pupilla; which serve to dilate the pupilla; and the other of orbicular fibres, running round the pupilla, which serve to contract it. But both MORGAGNI and HALLER, two great anatomists, deny the existence of the orbicular fibres; at least, they affirm they never could see them, either with the naked eye or the microscope. HALLER only admits some obscure radii in the uvea; so that here is a kind of pyrrhcnism in the anatomy and physiology of the eye.

Close behind the uvea, from the white circle round the origin of the septum, (which white circle is made by the closer adhesion of the choroides with the sclerotic there than any where else) I say from this white circle membranous processes of the choroides run close behind the septum or uvea, along the surface of the vitreous humor; and are implanted in the capsula of the chrystalline humor. They are called the processus ciliares, or ligamenta ciliaria. They are in themselves white; but tinged black with a black pigment; the origin of which anatomists have not been able to trace, upon the account of the minuteness of the parts.

LECT. The third and last coat of the eye is called re-  
 XXIV. tina. It is of a quite different texture from the  
 other coats, being soft like mucus; It is, as  
 WINSLOW expresses it, like a white soft paste  
 spread upon a fine reticular web. It reaches from  
 the insertion of the optic nerve to the origin of  
 the processus ciliares; adhering uniformly to the  
 choroides, in all it's extent. This coat is generally  
 and almost unanimously held to be an expansion of  
 the optic nerve. WINSLOW alone appears not a  
 little doubtful about the matter; what he would  
 have it to be he doth not tell, nor is it easy to guess  
 what else it can be. This may be reckoned another  
 pyrrhonism with respect to the structure and func-  
 tions of the eye. However HALLER, who in a  
 common way is not over credulous, sticks not  
 boldly to declare the affirmative.

We are to observe, that the optic nerve enters  
 the eye not directly in it's middle, and opposite to  
 the center of the pupilla, but to one side; to wit,  
 that towards the nose.

We shall now proceed to the humors of the eye;  
 and begin with the vitreous, because it is the largest.  
 It is a clear, and very liquid gelatinous substance,  
 contained in a fine transparent capsula, together  
 with which it forms a mass nearly of the appearance  
 and consistence of the raw white of an egg. It  
 fills the greatest part of the globe of the eye; to  
 wit, almost all that space, which answers to the ex-  
 tent of the retina, except a small portion behind  
 the uvea, where it forms a fossula, in which the  
 chrySTALLINE humor is lodged. The coat or capsula  
 of this humor is composed of two laminæ, very  
 closely connected, which quite surround it's mass.  
 And the internal lamina sends off a great number  
 of cellular productions through the whole substance  
 of the humor. At the edge of the fossula, where  
 the chrySTALLINE humor is lodged, the two laminæ  
 of the vitreous membrane separate, and form a  
 particular

X  
 and en-  
 dowed with  
 a considerable  
 degree of  
 pellucidity

X lamina



particular capsula, enveloping the whole chrystalline humor; of which next. LECT. XXIV.

The chrystalline humor, improperly so called, is a small lenticular body, convex on both sides, thick in the middle, and sharp and thin at the edges; in shape like a burning glass, and of a pretty solid and firm consistence, transparent like chrystal; whence it hath it's name. It is more convex on the posterior side, than on the anterior; being likewise a greater spheroidal segment, for it's convexity is elliptical. It is situated, as hath been said, in a fossula of the vitreous humor, behind the uvea, or septum, with it's middle directly over-against the center of the pupilla. It is composed of concentric laminæ, containing, within their pellucid membranes, a pellucid fluid, which, the younger the subject is, is both the more transparent, and the more fluid; when youth is turned, it becomes thicker, and inclining to yellow.

The aqueous humor, so called because it resembles water the most of the three, is a limpid fluid, with a very small degree of visciditv; lodged under the cornea, and filling the space between it and the chrystalline, on each side of the pupilla. There is more of it without the pupilla, than within it; the former division or camera being the larger of the two. It is restorable when let out, and therefore probably it is from time to time supplied, and absorbed by the small vessels, that open into the cavity where it is lodged.

The eye is furnished in a most wonderfully artificial manner with nerves, and blood vessels, in all it's parts.

The optic nerves arise on each side from the thalami nervorum optiçorum; and, after making a large curve, unite together at the cella turcica; then dividing, each runs obliquely to go out at it's proper hole in the sphenoid bone, and enters the

LECT. ball of the eye; and is entirely spent in forming the  
 XXIV. retina, which we have already described. The other  
 internal parts of the eye are supplied from branches  
 of the third and fifth pair.

The arteries of the eyes are furnished by the ophthalmic artery, which is a branch of the internal carotid. Here let us observe, that several branches of this ophthalmic artery are spent upon the optic nerve itself; and particularly one gets within it's medullary substance; running along it's axis, and entering the globe of the eye with it, is spread with it's ramifications all over the substance of the retina. The veins of the eye nearly answer the arteries. They return their blood into the ophthalmic vein; and from thence into the internal jugular.

Besides these vessels, that carry red blood, and are visible in a natural state; there are others which contain only serous, or lymphatic transparent juices; and therefore cannot be seen; or merely by their smallness are invisible; as the vessels of the cornea, iris, the membranes of the vitreous, and chrystalline humors; those that supply the fluids of the humors, the black pigment of the choroides, &c. some of these become conspicuous in inflammations, and nice injections. The rest we conclude to exist from reason and analogy.

Thus much for the globe of the eye itself. As it is necessary that the eye should be turned every way for the contemplation of such objects, as we have a mind to look at, it is furnished with muscles for that purpose. It hath six; four called recti or streight, and two oblique ones. They all arise within the orbit, and are inserted in the ball of the eye; forming, by their tendinous expansion, the tunica albuginea, as hath been said. The recti, as they act singly, or any two or more of them conjunctly, turn the eye round it's center in all imaginable directions; and therefore draw the pupilla towards

wards the nose, from the nose, upwards and down-wards, and in all the intermediate degrees of these motions; as the eye, being placed in an orbit larger than itself, and whose interstices are filled up with fat, is capable of all these motions. When all the four act firmly together, they must of course pull the eye backwards and inwards, pressing it towards the bottom and centre of the orbit.

The obliquus superior, by the course of it's fibres, and the direction it gets by passing through a cartilaginous pulley, and by the place of it's insertion, must turn the eye upwards, and pull it outwards from the orbit, and turn the pupilla downwards. The other obliquus, called minor, has an effect quite contrary; to wit, it pulls the eye downwards, and backwards towards the bottom of the orbit; at the same time turning the pupilla upwards.

Having thus taken a view of the structure of the parts, let us proceed to consider their uses and functions; and the manner in which vision is performed.

The rays of light proceeding in air, the fluid in which we live and breath, diverging from every point of the lucid body, first fall upon the transparent cornea. As the membrane of the cornea is much denser than air, and convex, it must give the rays a determination to converge towards some point behind it. The cornea itself is denser than water, and therefore refracts more. The aqueous humor under the cornea having a power of refracting pretty much the same as water, and therefore somewhat less than the cornea, the rays emerging from the cornea, and entering into the aqueous humor, must be somewhat, though very little, opened. For as the quantity of the aqueous humor is but small, and the far greatest part of it is spread broad between the cornea and the iris, and very little between the uvea and chrystalline, the passage of the rays through it is short; and therefore this

*not. however  
the Eye  
far enough  
to create  
distinct  
Vision,*



LECT. divergence, occasioned by the aqueous humor having a less refracting power than the membrane of the cornea, is very inconsiderable; and next to nothing.

From the aqueous humor they pass through the chrystalline lens. As this is considerably denser than water, or the aqueous humor, it hath a considerably greater refracting power. Some authors make it equal to a diamond in refracting; others make it somewhat less refracting than glass; but still more than water. The latter is by far more probable than the former; as the chrystalline humor is less dense than glass, which wants much of the density of a diamond. Be that as it will, as the chrystalline is a denser medium than the watry humor, and as both it's surfaces are convex, the rays must in passing through it, and at their emerfion out of it's posterior surface, acquire a much greater tendency to converge, and be drawn to a point, than they had got in their passage through the aqueous humor.

The rays having acquired so great a tendency to converge before their emerfion from the chrystalline lens, pass into the vitreous humor; which, having a refracting power less than the chrystalline lens, makes them converge still more, than they did while they were passing through it; in the same manner as a burning-glass convex on both sides makes rays converge in air to a point nearer the glass, than they would do, if the glass medium were continued. This I do not find observed by any author I have read on vision; though the whole geometry of the transparent part of the eye depends upon it. If the refracting power both of the aqueous and vitreous humor were not less than that of chrystalline, the great convexity of the latter would be of no use. The rays thus converging more in the vitreous humor, than they did while passing through the aqueous and chrystalline, at length fall upon the retina; and form an image or picture upon,

upon it, more or less distinct, as they are more LECT.  
closely or loosely collected. XXIV.

That this is the case is not a bare deduction of reasoning, but is demonstrated by experiment. Take the eye of an ox new killed, cut off a bit of the back part of the sclerotica and choroides, so as not to penetrate into the cavity of the eye, or let out any portion of the vitreous humor; fasten a piece of thin oiled paper, where the membranes have been taken off; this being done, place a lighted candle before the cornea, and you will see the image of the candle painted upon the oiled paper, invertedly.

The black pigments of the uvea and the ciliary processes, are of considerable use, as they suffocate and destroy all the rays that fall upon the black places; thereby hindering them from being reflected to and fro in their passage, and so reaching the retina; which, could it happen, would render the image on the retina confused. The picture thus formed on the retina excites the idea of the lucid object, or, which is the same, creates vision in the mind, or sentient principle.

That the retina is the immediate organ of vision, and not the choroides, as MARIOTTE and his followers would have it, appears from many reasons. The retina is next to the vitreous humor; and is the expansion of a nerve; whereas the choroides is a membrane chiefly vascular, with very few nerves distributed through it's substance. But nerves are the instruments of sense, not vessels. The choroides is found of various colours in various animals; but the retina is constantly of a white colour. And, in some fishes, there is a black membrane interposed betwixt the retina and the choroides. MARIOTTE's famous experiment, by which it is demonstrated that rays falling near the entry of the optic nerve excite no vision, proves nothing, because there is part of the choroides there, and therefore,

+ or gold  
beater's  
leaf.

Dr Porterfield  
ingeniously  
applies ano-  
ther ad-  
vantage of  
the black  
pigment

LECT. fore, if that membrane were the seat of vision, there  
 XXIV. would not be so large a portion of the bottom of  
 the eye insensible as there is. No doubt the branches  
 of the artery, that runs through the optic nerve,  
 and opens into the eye with it, being larger and  
 thicker spread where the insensible spot is, than else-  
 where, contribute not a little towards this insensibi-  
 lity, if it is not the sole reason. However, by this  
 experiment, we see that from the insertion of  
 the optic nerve, it's being nearer the nose than the  
 temples, there is this advantage gained; to wit,  
 that what is deficient in the one eye is made up  
 by the other; as the rays, that diverge from the  
 same point, can never be collected in the insensible  
 spot of both eyes.

We see then how by the convexity of the cornea  
 and chrySTALLINE humor, and by the refracting power  
 of all the humors of the eye, a picture of the lucid  
 object is formed upon the retina; and imprints the  
 idea of the object upon the sensorium commune, and  
 the sentient principle. But, if the figure of the eye  
 remained always the same in every respect; and  
 the situation of the refracting humors never were  
 changed; the picture would not fall upon the re-  
 tina exactly at all different distances of the object;  
 but in very distant objects might be formed in the  
 vitreous humor, before it touched the retina; and  
 in near objects would not be formed within the eye  
 at all, the rays converging towards a point beyond  
 the retina; and therefore distinct vision, especially  
 of pretty near objects, would only be performed at  
 one certain distance. By distinct vision is meant that  
 impression made on the sensorium, when the image is  
 most distinctly painted on the retina. Thus we see  
 in a camera obscura, the white surface, upon which  
 the images of objects are received, must be shifted  
 nearer to, or farther from the refracting lens, ac-  
 cording to the distance of the objects, in order to  
 paint them distinctly upon it. But we find by ex-  
 perience,



perience, that a sound eye sees distinctly at all distances, from the greatest, at which there can come light enough to excite vision, to within a few inches of the eye. Whence doth this change in the refracting power of the eye proceed, how is it brought about? To answer this, let us first observe, that there is some latitude to be allowed in the distinctness of vision. If the rays should not meet and decussate mathematically in the very extreme surface of the retina, but very near it, ~~either on the one side or the other~~, vision may be effected tolerably distinct, sufficient in a common way to answer our occasions. Secondly, at all considerable distances, from ~~twenty or thirty~~ yards to the greatest we can take in, the rays falling upon our pupilla nearly parallel, there is little or no change at all required in the eye, as they will all be collected into one point, physically speaking, whether the object is, for example, ~~fifty~~ yards off, or ~~five hundred~~ *five hundred*.

This being premised, let us take notice, that when the four recti muscles of the globe of the eye act conjunctly and firmly, they cannot but press it against the bottom of the orbit, and so render the eye shorter, according to the axis of vision, and therefore bring the retina nearer to the chrystalline lens; and when that conjunct action of these muscles is remitted, the figure of the eye will be restored. The shortening of the eye will accommodate it to remote distances, and the restitution of it's figure to shorter ones. That same action may make the cornea more convex, by pushing the aqueous humor forwards; which likewise co-operates towards the same purpose.

The construction likewise and dilatation of the pupilla, may alter the convexity of the cornea, especially if it be performed in the way HALLER would have it. For if the perforated septum, or uvea be enlarged in it's breadth, without diminution

LECT. XXIV.

X or a little within it,

X three or four

X five

LECT. of it's thickness, and much more, if it's  
 XXIV. thickness is enlarged at the same time, the aque-  
 ous humor must be pressed *quaquaversum*; and  
 if the chrystalline is ~~made~~ firm, the whole force  
 will be employed in pushing outwards the cornea;  
 so rendering it more convex: and this appears an  
 additional reason why the pupilla is diminished, in  
 order to look at near objects, to wit, by rendering  
 the cornea more convex, so making the rays meet  
 sooner than otherwise they would; but of the con-  
 striction and dilatation of the pupilla more after-  
 wards. +

+ Some regard  
 it to be due  
 to the thick-  
 ness of the  
 retina &c.  
 \* and by  
 their short-  
 ning pull  
 the chry-  
 stalline to-  
 ward the  
 cornea, sup-  
 posing it to  
 be moveable.

If the *processus ciliares* are furnished with true  
 muscular fibres, they may, by pushing back that  
 part of the vitreous humor they lie upon, occasion  
 a motion forwards of the body of it, which may  
 press outwards the chrystalline, and so remove it  
 farther from the retina. \* And, as this cannot be  
 done without pushing likewise forward the aqueous  
 humor, and making the yielding cornea more con-  
 vex, it will dispose the eye to make the rays that  
 pass through it more convergent than they other-  
 wise would be, and so render the vision of near  
 objects more distinct. But WINSLOW, who ad-  
 mits the longitudinal and circular fibres of the uvea,  
 speaks of these in the *processus ciliares*, as what he  
 had not seen himself; HALLER could never see  
 even the former; what then shall we say of the  
 latter? This therefore makes a third pyrrhonism in  
 the physiology of the eye; to wit, whether are  
 there, or are there not, true muscular fibres in the  
*processus ciliares*? If there are none, have they a  
 motion or not? If they have a motion, how is  
 it brought about? If the *processus ciliares* can  
 press upon the corpus vitreum, without a muscular  
 structure, why may not the pupilla be contracted  
 and dilated without it, and merely by a vascular  
 mechanism?

Upon these accounts I cannot help thinking, LECT.  
that, contrary to the opinion of some anatomists, XXIV.  
there are at least as many important things still du-  
bious in the eye, as in the ear.

Besides these motions and changes in the eye that adapt it to the distinct vision of objects at different distances, the contraction and dilatation of the pupilla serves to exclude some light where it is too bright, or receive more when it is too faint. Upon admitting the two series of fibres of the uvea, radial and circular, it is easily accounted for. HALLER, who asserts that he neither with his naked eye, nor with the microscope, could perceive the circular ones, and only obscure *radii* of uncertain use, thinks that the pupilla is constricted, not by muscular mechanism, but by a greater quantity of fluids being determined into the vessels of the iris, which makes it broader all around, and consequently it's hole, or the pupilla, less; so that the constriction of the pupilla is, according to his opinion, a violent state, and it's relaxation the natural one, without any muscular contrivance being concerned in either. Dr. WHITE combats this doctrine in the essay so often mentioned; to which I refer you.

*Even his  
scholar could  
not see Mus-  
cular fibres  
in the Uvea  
or Chrystat-  
lens, but  
seems to ad-  
mit their  
Existence.*

## LECTURE XXV.

*Phænomena of vision: some diseases of the eye: the inward senses: of watching, of sleep; and dreams.*

**I**N the preceding lecture we described the struc- LECT.  
ture of the different parts of the organ of see- XXV.  
ing; and explained how vision is performed: we  
shewed that it is by rays sent from every point of  
the luminous body, falling first upon the cornea;  
and from thence refracted by the humors of the  
eye, and collected so, as to form a picture of the  
visible object upon the retina; which retina being  
an expansion of the optic nerve, we judged to be  
the



LECT. the immediate instrument of vision, by which the  
 XXV. idea of the visible object is conveyed to the sentient  
 principle.

We likewise shewed, that the eye, in order for distinct vision of objects at different distances, must have a power of making some changes upon itself, in order to be accommodated to these different distances of objects. We explained the opinions of some of the most approved authors; and mentioned such doubts, as occurred to us, upon examining them.

As the sense of vision is the noblest, and most useful, as well as the most entertaining, of all the senses, we shall here consider, and endeavour to account for some of the principal phenomena relating to it; and solve some important problems that authors commonly take into consideration, when treating of vision; by which it's nature will be farther illustrated.

The first we shall consider is that question, Why, since the picture of the visible object is formed inverted on the retina, are objects seen by us in their true situation and posture, that is erected?

I answer, because the mind, or sentient principle, is affected according to the direction of the affecting cause; the mind perceives the object, and it's parts, in that situation from which the visual rays come; and as we see whole bodies under, or above one another, in the same situation they are placed, so we see the parts of one body either above, or under one another, as they really are; and consequently must see them erect, and not inverted.

Why, as we have two eyes, and two retinas, and therefore must have two pictures made of every object we see, one on each retina; I say, why do we see objects single, and not double?

Because, when the organ and sensory is rightly constituted, the picture on the retina affects similar  
 and

and corresponding places of the *sensorium commune*. LECT. XXV.  
 The brain hath places, right and left, corresponding with each other; and the two organs of vision, when sound, are so constituted, as that by being directed to view an object, the picture in the retina of each eye affects similar and corresponding places of the brain and sensory.

That this is the true solution, appears from the following experiment. Look on a lighted candle with your eyes directed towards it, as in common vision, and it appears single: but if you press one of your eyes with your finger, out of the proper direction, suppose towards the nose, then you will see two candles instead of one.

Some eyes are short-sighted; others are far or long-sighted. The former proceeds most commonly from a too great convexity of the cornea; as the latter proceeds from the cornea's being too plain, and not convex enough. By the cornea's being too convex, rays coming from distant objects, and falling almost parallel upon the cornea, are collected too soon into a focus; and form an image or picture within the vitreous humor, before they reach the retina; at the focus they decussate, and therefore fall upon the retina not collected or united, but diverging; and therefore create indistinct vision.

On the other hand, when the cornea, (which we observed in the description of the eye to be the portion of a less sphere than the globe of the eye itself;) I say, when the cornea is not convex enough, then the rays, when they reach the retina, are not collected into a focus, but converge towards a spot behind the retina, and so make vision indistinct.

I said, that the most frequent causes of short-sightedness, or long-sightedness, are the too great convexity, or too great plainness of the cornea. For the same may be likewise effected by the like proper.

LECT. properties of the chryſtalline lens itſelf; though no  
XXV. doubt much ſeldomer, than from the fault of the  
cornea.

The older we grow, I mean the more we are paſt middle age, in a common way we grow the longer ſighted; the aqueous humor not being ſo plentifully ſupplied as in youth, to keep up the plumpneſs and convexity of the cornea: hence long-ſighted people are called *preſbytae*, *ſeniores*; ſhort-ſighted people are termed *myopes*, that is, having eyes like mice, which ſee but at a ſmall diſtance.

Long-ſighted people are relieved by uſing convex ſpectacles; which make rays coming from objects fall leſs diverging upon the cornea, and therefore converge ſooner within the eye, than they would do without.

The ſhort-ſighted are relieved by concave glaſſes; which open the rays, and make them fall more diverging upon the cornea; upon which account their focus, or place of uniting into an image, is rendered more remote from the cornea, and nearer to, or upon the retina. But it muſt be obſerved, that there is likewiſe a ſhort-ſightedneſs occaſioned from a weakneſs of ſight; which commonly proceeds from a too ſmall degree of ſenſibility in the retina, and that obliges thoſe that labour under it to hold their eyes very near the object, to catch the greater number of viſual rays. Theſe people are relieved by very convex glaſſes, which are always great magnifiers, and by the magnifying power of theſe glaſſes, they are enabled to read or write, or deſcry minute objects, more commodiouſly than they could do without. Such people would ſee worſe with concave glaſſes, than with their naked eyes. This hint, which is ſeldom touched upon by writers on the eye and viſion, is of great importance in practice.



Some people can see with very little light. ILECT. knew a gentleman, who was turned of eighty, that XXV. could read and write without spectacles with less light, than the youngest of us commodiously can. Such people have sensible retinas, and widely dilat-able pupils, as owls and cats, and other animals, which hunt their prey in the night-time, have.

Others again can scarce see at all but in full day-light, and in the twilight are almost quite blind. Such have their retina more callous, and less sensible than it should be, and their pupilla not dilat-able enough.

Innumerable authors have wrote upon the eye and vision. The ancient writers, as AQUAPENDENTE and PLEMPIUS, though they may be worth the looking into occasionally, are much inferior to the moderns. WINSLOW's anatomical description of the eye is drawn up with his usual accuracy. LE CAT is very copious upon vision; but when he would seem to understand colours and refraction better than Sir ISAAC NEWTON, he will scarce gain your assent. The writers of courses of experimental philosophy, the chief of which are s'GRAVESAND, and MUSCHENBROEK (for DESAGULIERS omits optics) treat at large of the eye and vision; to which RUTHERFORTH; and Dr. SMITH, who hath wrote a complete system of optics, may be joined. Dr. PORTERFIELD's treatises upon the motions of the eye in the Edinburgh Medical Acts, are excellent: but he, without scruple, assumes as certain the reality of the longitudinal and orbicular muscular fibres of the iris, and those of the processus ciliares; which, as hath been already observed, are called in question by some of the ablest anatomists of the age.

The eye, and the parts that have an immediate reference to it, are of so delicate a frame, that innumerable different disorders are incident to them. At the same time the parts are so minute, and their

Z

functions

LECT. functions so manifold and intricate, that they are  
 XXV. with the greatest difficulty distinguished from one  
 another; and the chirurgical operations requisite to  
 remove, or relieve them, require so nice a skill, and  
 so rare a dexterity of hand to perform them aright,  
 that there is scarce any thing of so great difficulty  
 in the whole art of healing, whether physick or  
 surgery, as to be an able oculist. It really requires  
 the whole man.

Wherefore it is not to be expected, that in a  
 compendious course of physiology, a very confi-  
 derable part of the whole of the diseases of the eye  
 can be treated of.

I shall say something upon a few of them; such  
 as are either most frequent, or most important;  
 chiefly with a view to shew the connexion between a  
 knowledge of the animal œconomy, and the ra-  
 tional practice of medicine.

And first, the eyes are sometimes as it were de-  
 luded with a watriness. This distemper is called  
 epiphora. It is too plentiful a secretion of the la-  
 chrymæ; and as that fluid is naturally saline, if it  
 is always in too great plenty upon the surface of the  
 eye, it vellicates the tender cornea, and the insides  
 of the eye-lids, and derives a flux of humor to the  
 parts; renders the eye impatient of light, and cre-  
 ates many other inconveniencies.

The cure of this disease is obtained, after bleeding  
 and repeated purges, blistering and epispastics,  
 by the application of safely astringent and cooling  
 medicines externally to the eye. They may be used  
 either in the form of collyrium, or ointment. Fair  
 water will sometimes do a great deal alone. Alum,  
 and saccharum Saturni are proper to increase the  
 astringent virtue of cold water; and are the chief  
 of the astringent class here. Tutty is often added,  
 which seems to operate partly by it's grittiness, as  
 well as it's astringency. But the vehicle in col-  
 lyriums is never to be too much saturated with acid  
 and

+ acid

and saline ingredients. Every thing applied to the eye must be temperate and mild.

LECT.  
XXV.

Sometimes in obstinate epiphoras, setons or issues are necessary.

The opposite distemper to this is a driness and stiffness of the eyes, arising from a defect of lachrymæ; and the unctuous humor separated by the *glandula Meibomiana*.

The defect of these salutary secretions makes the eye-lids move over the globe of the eye with uneasiness, and creates a disagreeable sense of driness and stiffness; and as moisture is in some measure necessary for the smoothness and brightness of the cornea, it may in some degree impair the clearness of sight.

Application of warm water, rendered more penetrating by attenuating and resolving vegetables, as camomile or elder flowers, with emollients, as *altbea*, *malva*, and the like, are here proper. A prudent use of internal mercurials will conduce to open obstructions.

The eye may be inflamed in it's various parts, and this distemper is called ophthalmia. If the inflammation is within the cornea, it is most to be feared, and ought the most speedily to be carried off. A violent pain within the cornea, with an extreme impatience of light, should make the practitioner suspect the iris or uvea to be inflamed; and to prevent suppuration, the briskest methods ought to be put in execution without loss of time. Plentiful repeated bleeding, cool purges, extreme thin humid diet, cupping, blistering, shaving the head, bathing of the feet in warm water, semicupiums, &c. while all light is carefully kept from the eye, are the chief remedies.

A total deprivation of sight, while all the parts of the eye preserve their natural appearance, is called *amaurosis* or *gutta serena*. This disease is attended with a relaxed pupil, which doth not con-



LECT. tract itself when a lighted candle is held near the  
XXV. eye.

 This distemper is an obstruction of the optic nerve, either at it's origin in the brain, or somewhere in it's progress towards the eye.

It is too frequently incurable. After suitable evacuations, the most penetrating cephalics and antiparalytics, proper mercurials, and mineral waters, especially the sulphureous, as those of Harrogate, Nevil-Holt, Moffet, Bath, or Aix la Chapelle, are most to be depended upon.

The last distemper we shall touch upon is the cataract. This is an opacity immediately behind the pupilla, which intercepts the rays, and hinders their transmission to the retina.

There have been great disputes concerning the nature and seat of cataract: some contending that the opacity is in the capsula of the chrySTALLINE, or some opaque membrane between the pupil and the chrySTALLINE; and others, that it is in the body of the chrySTALLINE itself; and it is certain, that it is ofteneft in the body of the chrySTALLINE, though sometimes it may be in it's capsula.

However that be, the dispute is of no great significance; for the cure is the same; to wit, with a blunt needle introduced into the outside of the eye, to catch hold of the chrySTALLINE, and depress it, so as to remove it out of the axis of vision: if it remain depressed, the vitreous humor takes it's place; and if the operation succeeds, the patient sees by the cornea, the aqueous humor, and the vitreous, without the chrySTALLINE; and therefore, the sight thus obtained must fall much short of the natural sight: but any degree thereof is infinitely preferable to total blindness.

*and may be  
relieved by  
a convex  
reading glass.*

But there is always great uncertainty in the effects of this operation, and the practitioner that values his credit and reputation, should never pretend to warrant it's success.

We

*Here a new Lecture should begin.*

OF THE INWARD SENSES.

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We have now gone through the external senses; **L E C T.**  
and as physiologists use to subjoin to their enquiries **XXV.**  
into them an account of the internal senses, that is, the different species of thought, we shall so far comply with the custom, as just to touch upon them here.

We have shewn, in the course of these lectures, that the brain, properly so called, as distinguished from the cerebellum, is the seat of the animal faculties, that is, of perception and volition of every kind. An apoplexy, which is created by pressure upon the brain, takes away all sense, thought and voluntary motion.

This there is very good reason for believing; but we likewise confessed, that we knew nothing of the particular uses of the different parts of the brain. We know that there is a great variety of parts in the brain, and that there is an infinite variety of different kinds of thought; but we do not know where one species of thought hath it's seat, more than another. No doubt, as nature does nothing in vain, there are different real motions, of some kind or other, exercised within the brain, answering to every different modus of thinking; as a musician makes different changes upon his instrument, answering to the different parts of every tune he plays: but, as we know nothing of the particular modus, we should not go beyond general positions.

And therefore what **DES CARTES**, **WILLIS**, and others after them, have, without any manner of proof, delivered concerning the functions of this or that particular portion of the brain, are to be looked upon as idle chimæras.

**STENO**'s discourse on the brain, which **WINSLOW**, his relation, hath inserted in his anatomy, is well worth reading upon this subject.

So that to consider the different operations of the mind belongs to a course of logic, rather than to one of the animal œconomy; any farther than

LECT. the taking notice in general of the connexion between *mens sana* and *corpus sanum*.

But there is a subject nearly allied to this, that the physiologist hath much to do with; as it is important both in the speculative consideration of the animal œconomy, and in the practice of medicine; to wit, the consideration of the state of watching, and it's opposite, that of sleeping and dreams.

Watching is that state in which, besides every other function, those of the brain, or the animal functions, which may be reduced to the heads of sensation, thought, and voluntary motion, go on. Sleeping is that state in which the animal functions, to wit, sense, thought, and voluntary motion, are suspended, or taken away for a time; while the others continue to be exercised.

All animals, as far as we know, sleep a great part of their time. The human species, reckoning from birth to the grave, sleep little less than half their time; and the natural season of sleep is, with us, in the night.

Let us ~~then~~ enquire first into the causes of sleep; and then explain it's effects and use.

The common natural antecedent causes of drowsiness and sleep, is watching a sufficient time, and labour or muscular motion. While we are awake and up, though we live ever so sedentary a life, our senses are exercised, and we have some muscular motion. Every sense, every muscular motion creates a stimulus more or less, which urges on the circulation; the continuation of which urgency renders the blood more exalted, and occasions a dispendium of it's thinnest parts; and especially of the nervous juice.

If to watching bodily labour is added, drowsiness and sleep is created so much the sooner; the circulation being so much the more urged on, and the exaltation and dryness of the blood, and the  
waste



waste of the nervous juice so much the more pro-  
moted. LECT.

XXV.

The spirits being wasted, we feel a trouble of keeping the body erect; which requires an incredible force of muscles, even while we are sitting; much less are we fit for walking, in which, besides maintaining the erect posture of the body, many and large muscles must be strongly actuated; we are unfit for close thinking; our eye-lids fall, and our heads nod: we then deliver ourselves up to rest in a decumbent posture; our ideas grow first confused, and next delirious. At length we fall asleep; and lose the consciousness of what further is going on, within us, or about us.

In this natural succession of sleep to watching, the principal cause of sleep is a penury of spirits; they having been exhausted by watching or labour; during which, no doubt, a great quantity of them exhale.

With this cause of sleep, the removal of every thing, that either the mind, or the senses, or muscular motion excites, co-operate. Absolute rest of the mind, a decumbent posture of the body, silence and darkness, are comprehended under this head.

Besides this natural cause of sleep, whatever wastes the strength, independently of labour or long watching, inclines to sleep; as loss of blood. Hence calves, which butchers bleed often to make their flesh white, are always drowsy. To this head may be reduced excessive pain new got over, which inclines to sleep. This cause coincides with a penury of spirits.

To the same head may be likewise reduced such causes of sleep, as draw powerfully from the head; as blisters, which you will often in practice observe to promote sleep, and act like an opiate, as they begin to take hold. Bathing the feet in warm water hath a like effect. These act by creating such a

LECT. derivation of spirits to another place, that the  
 XXV. nerves destined for sense and voluntary motion are  
 defrauded and collapsed.

Under this head opiates likewise may be comprehended, which take off irritation universally, as well in the *primæ viæ*, where they immediately act, as in the whole sensorium; it being in effect the same thing to have spirits not in motion, as to want them.

And to this head HALLER refers the drowsiness, which in all animals is observed to be produced after a full meal. This he thinks is not occasioned by compressing the aorta, and so sending more blood to the brain, and compressing the origin of the nerves; but by the stimulus of the aliments, which derive spirits into the stomach, and it's neighbourhood, in order to promote digestion. His chief argument for that opinion is, that some animals have no brain at all, and yet cease not to be drowsy after feeding; no doubt he means insects.

Sleep is likewise produced by a compression of the brain, of whatever kind; whether mechanical, as by extravasated blood, pus, or lymph; or, in general, whatever creates apoplexy. This compression of the brain hinders the secretion and flux of the spirits, at the origin of the nerves.

To this class HALLER reduces fermented liquors, and ardent distilled spirits.

But may they not act, at least in part, like opiates; and may they not likewise create a derivation of spirits into the stomach, to digest and conquer them?

Sleep, therefore, is produced by a penury of nervous juice; or by any cause that either calls off the spirits from the head; or hinders their separation there, and their flux into the nerves, which influence the organs of sensation and voluntary motion.

So

So that the emtiness and collapsing of these nerves, is the immediate physical cause of sleep. LECT. XXV.

BOERHAAVE, in accounting for sleep, lays a considerable stress upon the brain's having ventricles or cavities, which the cerebellum hath not. HALLER rejects this ancillary cause, as he says that sleep is common to all animals; and that some species want ventricles in the cerebrum. ~~But, by what I find, both birds and fishes, as well as quadrupeds, have these ventricles, he must, therefore, mean insects.~~

So much for the causes of sleep; let us next consider it's effects and use. In sleep all stimulus of the circulation, either from sensation or voluntary muscular motion ceasing, the motion of the blood becomes slower; the dispendium of liquids of every kind, and of spirits in particular, becomes less; the vermicular motion of the stomach, and the peristaltic motion of the intestines is milder; therefore digestion goes on more slowly, and hunger is put off; respiration becomes rarer and less deep. The animal is rendered colder; for though we seem hotter in bed than when up, that is owing to the bed clothes; for if we sleep in our day clothes, we grow colder. Hence perspiration is diminished naturally by sleep; and if at times it is increased, it is owing to our covering when in bed. Absorption, by the inhaling vessels of the skin, is increased, as KEILL hath proved. Animals that sleep all winter, are extremely cold all the while; colder than those that are awake.

And thence too great a continuance of sleep produces all the effects of a too slow circulation; as, corpulency, drowsiness, cachexy, <sup>and</sup> a great impairing of memory.

The natural use of sleep is chiefly to produce a recruit of spirits, and other humidity of the blood and juices. For as the secretion of spirits goes constantly on, and the dispendium is diminished, their quantity is increased and accumulated in the brain and



LECT. and sensory: so that the animal next morning is  
 XXV. restored to the same state, with respect to spirits, it  
 enjoyed the morning before.

In time of sleep the motion of the blood being slower, abrasion of the solids is diminished; and therefore nutrition hath the balance in it's favour; and the congregation of similar particles of the juices, and consequently their secretion, is favoured and promoted, and particularly that of fat.

Dreams are only imperfect sleep; that is, they are created when some parts of the brain are in the same physical condition they are in while the animal is awake; while the rest of the parts are in the state of sleep. When some parts of the sensory, that are subservient to this or that sense, or in this or that imagination or thought, have their nerves pervious; and allow a flux and reflux of spirits through them, while the rest do not. And as we are so framed, as that certain motions and impulses in the sensorium are accompanied with certain sensations and thoughts, in whatever way these motions and impulses are brought about; therefore, in the state we have mentioned, we have these sensations or thoughts excited, without the real impulse of external objects, and without the determination of our wills.

This account of dreams DES CARTES saw, amidst his manifold groundless whims and chimæras, in his treatises *De homine* & *de fœtu*: here he dreamed right for once. BONTEKOE, a disciple of his, but who, in many parts of physiology, is a præcursor to BOERHAAVE, hath well explained and enlarged upon it.

And hence the extreme vividness of dreams, that sometimes affect us, may be accounted for; for while the other parts of the sensory remain impervious, and in a state of sleep, the flux of the spirits may be as brisk, or even brisker, through the dreaming part, than when the man is awake and acted

acted upon by external objects, or setting his LECT.  
thoughts in motion by the determination of his XXV.  
will. }

Hence likewise the reason appears, why bad sleepers are great dreamers; and it may likewise be accounted for why we are, *cæteris paribus*, aptest to dream of those things that make the strongest impression upon us when we are awake; for instance, HORACE'S dream; as those parts of the sensory, which are most rummaged through by spirits in the day-time, are likely to remain the most pervious when we are asleep.

And the phænomena of sleep-walkers may be accounted for by a lively dream affecting them in such a manner, as to influence the muscles of voluntary motions to concur with it, while the other parts of the sensory, which have no connexion with that dream, are obstinately locked up in sleep.

## LECTURE XXVI.

*Of the female organs of generation; the menses; some diseases of the parts.*

WE have gone through all the principal func- LECT.  
tions of the animal œconomy that relate XXVI.  
to the life, the duration, and well-being of the in- }  
dividual; it now remains to take into considera-  
tion the affair of generation; that function, or ra-  
ther group of functions, by which the species is  
propagated, and as it were perpetuated; to which,  
if an account of the embryo and foetus is added,  
these lectures will be concluded.

To use the words of the most ancient writer, whose works have been handed down to us, the divinely inspired MOSES, GOD created mankind male and female. Woman was added as an helpmeet for man in the domestic affairs of life, but especially to conceive and bring forth children, and

to

L E C T. to suckle and take care of them when brought forth.  
XXVI.

As the offices of the two sexes in generation are different, a diversity of organs was requisite. We shall first take into consideration the structure of the female.

Woman in general is of a more delicate make than man; the fibres more soft and flexible; the muscles less brawny; the bones smaller, and the ~~nature~~ and strength less. This difference betwixt the sexes commonly holds in the human species; but in the brute kind, the contrary rule prevails in many instances; the females being stronger and stouter than the males, that they may the better defend their young ones.

Besides, the pelvis in women is proportionably larger than in men, to allow space for the increase of the foetus during pregnancy; and in breathing they use the diaphragm less, and raise and widen the thorax more than men, that their respiration may be the less incommoded in that state, as hath been already observed.

The principal parts of generation in the female sex, are the uterus, the vagina, the tubæ fallopianæ, and the ovaria.

The uterus or womb, the habitation of the foetus, is situated between the urinary bladder, which is placed before it, and the intestinum rectum, which is behind it. In a grown woman, not with child, it is about three fingers breadth long, two in breadth where it is broadest, and one in thickness: it is of the figure of a flat flask, convex before and behind, with edges inclining to sharp. It's broadest extremity, which is called it's bottom, is uppermost; and it's small part, called its ~~convex~~ or neck, is downwards. It is covered over with the production of the peritonæum; two portions of which, one on each side, fasten it to the sides of the pelvis, and are called the ligamenta lata.

The

+ Nature

cervix +



The uterus, when unimpregnated, hath but a very small cavity, it's walls being very thick. The cavity is in some measure of a triangular shape; it is lined with a very thin membrane, which is a continuation of the epidermis, *from the external surface of the*

The uterus is made up of a compacted cellular substance, with a copious intertexture of blood vessels. There appears something like muscular fibres amidst the cellular substance; especially in women new delivered, variously distributed in little circles. *respect par it.*

The smaller and lower part of the uterus, called it's neck or cervix, abounds with callous *rugæ*; in the interstices of which there are mucous sinuses, and here and there round vesicles full of a very pellucid lymph. Where it opens into the vagina, it forms a round protuberance, not unlike the glans penis, called *os uteri* and *os tinæ*, divided by a *rima*, or chink; on which protuberance there is plenty of a mucous glutinous liquor, furnished by numerous sinuses there. This glutinous liquor serves to shut the *os uteri* in pregnancy.

The vagina, or canal of the uterus, as Winslow chooses to call it, is about six or seven inches long; it is stretched from the *os uteri* to the pudendum; it is of the same texture with the uterus, to wit, cellular, with numerous blood vessels interwoven. It's inner and concave surface hath several *rugæ* or wrinkles. There are likewise nervous papillæ spread over it, which render it the more sensible. It's external orifice is surrounded with muscular fibres, which constrict it.

The uterus, as hath been said, is plentifully stored with blood vessels; they are furnished from the hypogastrics, by which likewise the inner and greater part of the vagina is supplied. It's outer extremity is furnished from the external hæmorrhoidal.

LECT. As the adult females of the human species are  
 XXVI. for a great part of their lives subject to a periodical  
 monthly flux of blood from the parts we have  
 just now been describing, the consideration of which  
 is of the utmost importance in the practice of physic,  
 as well as in the animal œconomy, we shall, before we proceed  
 farther in our enquiries into generation, treat of it's nature,  
 causes, and effects.

+ *Stature* A girl in health, about the time she arrives at her full ~~nature~~, sometimes before, and sometimes later, which in our climate is commonly about the age of fourteen or fifteen, after having for some time suffered, more or less, heavy dull pains in the loins, and parts adjacent to the uterus, head-aches, out-breakings in the skin, and other symptoms, is at length surprized with a new appearance, to wit, a flux of red blood from the orifice of the vagina. This having continued two, three, or more days, during which time the former inconveniencies either greatly abate, or wholly vanish, stops of itself, and returns about a lunar month, or four weeks after. This periodical flux in our climate generally continues from it's first appearance to near the age of fifty, provided the women are in health, except during pregnancy, and while they are nurses, at which times it is commonly interrupted. The time of the continuance, and the quantity of the evacuation, differs in some measure according to the climate, but chiefly according to the temperament and way of living of the woman. In temperate countries it is more plentiful; in hot countries less, because perspiration is there greater; and in extreme cold countries least of all, from the constriction of vessels. A sanguine plethoric habit, plentiful diet, an unactive, easy life, greatly increase it's quantity and space of continuance; and the contrary circumstances diminish them. Three or four days continuance, and eight or ten ounces in quantity, are nearly a medium. Some women, of tender,

tender, delicate constitutions, are much incommoded L E C T.  
 some time before, and immediately upon the ap- XXVI.  
 proach of the flux; others, more robust and ~  
 healthy, hardly feel any inconvenience at all that  
 way, and scarce have warning enough to provide  
 for decency.

As the females of no species of animals but the  
 human are subject to the monthly flux, unless we  
 should give credit to stories told by travellers of  
 some of the ape or monkey kind, and men are free  
 from it, it hath much exercised the heads and pens  
 of physiologists to assign the true causes thereof.  
 The time of it's revolution being in a general way  
 pretty exactly a lunar month, it was natural at first  
 to imagine, that the influence of the moon was  
 principally concerned in bringing it about, especi-  
 ally in ages where true natural philosophy, and  
 knowledge of the animal œconomy, were at a low  
 ebb, and a superstitious credulity in astrology and  
 planetary influences had gained much ground: but  
 it is easy to confute that opinion, since there is not  
 a day in the month or year, in which thousands of  
 women do not suffer this flux; besides, if the in-  
 fluence of the moon were the principal cause, why  
 should it not affect the females of other kinds be-  
 sides the human?

When chemical philosophy came into vogue,  
 and prevailed in the theory as well as the practice  
 of medicine, ferments were imagined in every part  
 of the human body, and scarce any function was  
 explained without assuming some ferment or other;  
 and amongst the rest, the menstrual flux was as-  
 cribed to an uterine ferment. But in proportion  
 as the structure of the human body, and the na-  
 ture of animal juices, were more accurately enquired  
 into, and better understood, and chemistry itself  
 was improved and rendered more rational, ferments  
 in the animal œconomy were exploded; to-  
 wards which none contributed so much as the im-  
 mortal

*+ These I  
 find have  
 gained the  
 credit with  
 the celebrat-  
 ed Linnæus.*

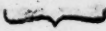


**LECT. mortal BOERHAAVE.** And in the uterus in particular, there is as little reason to suppose a ferment, as in any part whatever, where there is nothing either acid or alcalious, nothing but arterial or venous blood, and smooth mucous juices: besides, when the menstrual flux is stopped at it's natural passage, it often makes it's way by other outlets, insomuch that there is scarce any imaginable discharge of blood, but what hath been brought on by such a stoppage, as hæmorrhages by the nose; spitting, vomiting of blood, bloody stools, &c. and even hæmorrhages through the pores of the skin. And this observation leads us naturally to the true cause, to wit, plethora, or a too great quantity of good blood; as it would be absurd to imagine there can be ferments in all the places through which the menstrual flux, when stopt at the uterus, makes it's way.

Plethora then is the true cause of the menstrual flux; which, when it is come to a certain height, distends the arteries of the uterus, which are there so numerous, and gradually dilating their branches, at length forces blood into canals arising from these branches, and opening into the cavity of the uterus, which before only admitted a serous or lymphatic fluid, serving to keep that cavity moist, and hinder the walls of the uterus from growing together.

But you will ask, how is this plethora produced? and, when produced, why is it determined towards the uterus, there to be expelled, rather than by any other way? I shall answer both these questions.

When the stature is at it's height, or nearly so, and not only the bones, but the viscera, or at least their membranes, are become so hard, and as it were, callous, as to resist being farther enlarged by the action of the heart, and amongst other parts the uterus, the virgin continues to make as much chyle and blood as formerly, her appetite and

and digestion continuing the same, supposing her L E C T.  
to be in health; but the space for containing it not XXVI.  
increasing as before, because the vascular system is   
not proportionably enlarged, there must of course  
a plethora be produced.

This plethora must be determined towards, and exert it's greatest force upon the uterus, because that viscus, being plentifully supplied with large blood vessels, is lodged in a place where it hath abundance of room to be extended in, and receive a surcharge of blood into it's vessels. The pelvis of a woman, as hath been said, is larger than that of a man; and the uterus in a natural contracted state is small, and therefore doth not fill it's cavity in the same degree that most other cavities of the body are filled. The uterine arteries being distended, the uterus will be enlarged in all it's dimensions, it's cavity will become more capacious, as well as it's walls thicker: by this means, it's vascular system will approach nearer to straight lines, and not be so much rolled up like thread in a clew, as it was before in it's contracted state, and therefore a farther influx of blood into it will be favoured. And if it be allowed that air has not a free admission into the cavity of the uterus, which is more than probable from the closeness of the pudendum, the foldings and rugæ of the vagina, the smallness of the rima of the os tincæ, while all the passage leading to the uterus is kept moist, and besmeared with mucus, like wet leather used in experiments made with the air-pump; I say, if this be allowed, the increase of the cavity of the uterus must in some measure form a Boylean vacuum, which will greatly favour and promote the dilatation of the small arterial tubuls, which open into that cavity, and so facilitate the transmission of red blood through them, instead of serum or lymph.

LECT. A man hath a less pelvis than a woman; he  
 XXVI hath no uterus nor vagina, and therefore he can  
 have no such flux: besides, his fibres and vessels  
 being, in a general way, more rigid and stronger  
 than in the female sex, he is less liable to plethora;  
 the overplus, as it is gradually accumulated, being  
 more apt to be discharged by urine or perspiration.  
 Accordingly SANCTORIUS hath observed a periodical  
 discharge in men by urine, answering to the  
 monthly purgations of the sex. However, writers  
 of observations have recorded instances of some  
 men having monthly hæmorrhages by piles, and  
 otherwise; but such are uncommon.

Brutes have no menstruous flux, as hath been  
 said; the chief reason seems to be, because in them  
 the uterus is thin and membranous, and rather a  
 vagina continued, neither so fleshy, nor so vascular  
 as in the human species.

If it should be asked, why is this flux periodical,  
 and why the period is nearly within the space  
 of a lunar month? I answer, that from the nature  
 of the thing it cannot be constant. Immediately  
 after one discharge is over, there remains no  
 plethora, otherwise the flux would have continued,  
 but rather a penury of good blood. In that situation,  
 the cellular and vascular texture of the uterus  
 quickly restores it to it's former smallness by its  
 great contractility. The plethora requires some  
 time to form itself anew, from it's slightest beginning  
 to it's height; and while it is forming, the vessels  
 of the uterus are gradually more and more distended,  
 from the largest arterial trunks to their smallest  
 serous emissaries, till these last are so stretched,  
 as to admit red globules to be disembogued into  
 the cavity of the uterus, and then a new flux  
 succeeds. This discharge, therefore, must be  
 periodical, not constant. We need not puzzle  
 ourselves to account for the period's being either  
 monthly, or in a general way regular, and nearly  
 within



within the same limits. Some period of no great LECT.  
latitude there must be, as well as the human sta- XXVI.  
ture runs commonly between five and six feet; and  
that period in individuals must continue nearly the  
same, as long as the constitution, age, and manner  
of living continue the same; and if these vary,  
the circumstances of the flux vary likewise.

The bulk, if not the whole of the monthly discharge, comes in a common way from the uterus itself, and not from the vagina: this hath appeared by ocular demonstration in subjects that have died with the menses upon them. By pressing the uterus in such subjects, blood hath been seen oozing into it's cavity through small pores, and it's inside hath been seen besmeared with blood. At the same time it is probable, that in some extraordinary cases it may come from the vagina; as in some pregnant women, who yet cease not to have their accustomed monthly purgations: and in morbid cases, when the os uteri hath been constantly shut, and it's cavity filled with an ulcerous sanies, yet the menses have flowed. But these extraordinary instances only prove, that a stoppage of the proper uterine vessels may occasion an opening of like vessels in the vagina, and be in some measure supplied by that violent effort; not that in an healthy state nature uses that way.

The menstruous blood is not of that corrupted venomous quality that many ancient authors, whom Pliny hath transcribed, have believed it to be; they had no encouragement from the writings of Hippocrates to think so; on the contrary, the divine old man, who closely followed nature, without being prejudiced by hypotheses, expressly says that it is pure, like blood flowing from a victim. The origin of these foolish conceits seems to have been this, that in hot countries, from which arts and sciences first sprung, if proper ablutions were not used, menstruous blood extravasated within the

LECT. uterus, and detained in some measure within the  
 XXVI. vagina by it's rugæ and contractility, must needs  
 contract an higher degree of putrefaction, than it  
 does in more temperate climates; and therefore  
*coitus cum muliere menstrua* was found to be attended  
 with inconveniencies to the male; and hence it is  
 forbidden in the Levitical law; and hence purefi-  
 cations were ordered, which are still in use all over  
 the East. From all which mankind, ever preci-  
 pitant in drawing conclusions, inferred, that men-  
 struous blood is in it's own nature venomous, and  
 therefore expelled, to free the habit from some-  
 thing hurtful and deleterious, and from less to  
 more came to harbour a thousand groundless and  
 extravagant notions concerning it's poisonous effects.

In the decline of life, near the age of fifty, in  
 our temperate climate, the menstrual flux com-  
 monly ceases, because the texture of the uterus,  
 the vascular as well as cellular, then becomes so  
 rigid, as not to yield to the distending force of  
 the blood, impelled through it by the action of the  
 heart, which is then diminishing, so as that red  
 globules may be forced into the lateral arterial  
 ducts that open into it's cavity. But instances daily  
 occur of it's continuing some years longer; and  
 in some rare cases it hath been known to go on even  
 to extreme old age.

About this critical time of life, when the menses  
 are near ceasing, and for some time after they  
 are ceased, women are liable to a great variety of  
 complaints, which often fix in obstinate diseases,  
 that at length wear them out; as rheumatic and  
 scorbutic pains, head-aches, vertigo, hysseric dis-  
 tempers, fevers of different kinds, cutaneous foul-  
 nesses, and, in a word, every disease that may owe  
 it's origin to plenitude of vessels, another strong  
 argument that plethora is the mother of the men-  
 strual flux. Seasonable bleeding, keeping the body  
 soluble, a cooling, temperate diet, and a proper  
 regimen

regimen of life, are the chief preventive measures here.

LECT.  
XXVI.

The celebrated Dr. FREIND hath written an elaborate and elegant treatise on this subject, intitled *Emmenologia*; but you are to observe, that he supposes a rupture of blood vessels in every return of the flux. This is an erroneous, as well as unnecessary hypothesis; if the case were so, the uterus would probably be much more subject to inflammations and ulcers, from the numerous *vulnuscula* in the broken vessels, than it is: it is a violent supposition, and not analogous to the mild and safe procedure of nature in every other respect; and unnecessary, because dilatation sufficiently accounts for the *phænomena*. This remark is necessary, that we may profit aright by that otherwise useful performance. Dr. SIMPSON's system of the womb likewise highly deserves reading.

We now proceed to the other parts of generation in women; to wit, the *tubæ Fallopianæ*, and the ovaria, otherwise called *testes muliebres*.

We observed that the uterus, in it's contracted, unimpregnated state, hath a small cavity, somewhat of a triangular figure; at each of the two angles of this cavity that are uppermost, on each side of the fundus uteri, the *tubæ Fallopianæ* open by two small orifices, which in a dead subject with difficulty admit an hog's bristle: from this small opening each tuba proceeds somewhat transversely from the fundus, towards the lateral parts of the pelvis, running between the duplicatures of the *ligamenta lata*, their diameters gradually and remarkably augmenting to their extremities, where they are about a quarter of an inch wide: they run not streight from the uterus, but wind in such a manner, as to turn their wide open extremities towards the ovaria; these extremities are jagged or scalloped: their external membrane, or covering, is from the *peritonæum*; their proper coat is plentifully



LECT. tifully furnished with vessels; there are some ob-  
 XXVI. scure, seemingly muscular fibres interspersed, sup-  
 ported by a spongy cellular texture.

The ovaria are two whitish, oval, flat bodies, situated on the sides of the fundus uteri, to which they are joined by a kind of short ligament, and inclosed, together with the tubæ Fallopianæ, in the duplicature of the ligamenta lata: their substance is cellular and close, without fat: in it there are found, even in the ovaria of virgins, little round vesicles, called ova, or eggs, of an uncertain number, commonly ten or twelve, full of a transparent coagulable fluid: these ova adhere closely to the texture of the ovaria.

The ovaria and tubæ Fallopianæ are supplied with blood vessels from the spermatics, which have nearly the same origin in females as in males; to wit, the arteries from the aorta, near the rise of the emulgents, and the veins from the vena cava and emulgent vein. These inosculate with the vessels that go to the uterus.

We shall conclude this lecture with a brief account of some of the diseases of the parts we have been describing.

The uterus is seldom seized with true inflammation, and scarce ever without external violence, as rough treatment in birth. It's blood vessels are highly dilatable, which renders it the less susceptible of inflammation; but both it and the vagina are liable to be ulcerated, and yield a malignant ichor.

The menstrual flux may be excessive in quantity, or it may be deficient, though continuing in some measure; or it may be totally obstructed through disease, before the natural term of it's stopping, and without the effect of being pregnant, or suckling.

The menses in a woman of a good habit of body are seldom obstructed, but by catching cold, especially

especially about the time of menstruation; in which *L E C T.* case, before the habit is vitiated by their retention, *XXVI.* whatever relaxes the uterine vessels, and at the same time adds to the impetus of circulation, will force a return thereof.

Emollient fomentations applied to the orifice of the vagina, warm baths, and preserving a warmth in the parts, answer the first intention.

The second is brought about by medicines which are commonly called emmenagogues; they operate chiefly by raising the pulse; and as the uterus, by its structure and situation, is extremely susceptible of dilatation, the increased force is most likely to be determined towards it.

The most safely warming vegetables, which have no remarkable astringency, produce this effect; artemisia, favin, bryony, aristolochia, are chiefly used; in the mineral kingdom, borax, chalybeats, and proper mercurials; and in the animal, castor, are most depended on.

But if with a retention of menses there is joined a bad habit of body, either as the cause of the retention, or the effect of its continuance, the indication is first to rectify the habit, and create a plethora, before we proceed to stimulate the menses; and when that is done, then and no sooner administer forciers: there are frequent miscarriages in practice for want of the observation of this rule.

As I have no favourable opinion of the doctrine of derivation in blood-letting, I think that opening a vein in the foot can scarce ever be of service to promote the menses, except where there is a very great plethora; in that case it may be requisite, in order to give a freedom to the circulation, and a due oscillation to the arteries.

An excessive flux of the menses is restrained by rest, by a cool temperate diet, and by astringent and incrassating medicines: farinaceous vegetables

LECT. and milk, with fresh broths, are proper nourishment; allum is the styptic most to be depended upon; Jesuit's bark may be of good service, both as an astringent, and as it checks febrile motions: opium and it's preparations, unless well corrected by coolers and increasants, are here rather detrimental than serviceable; though they are excellent remedies in other fluxes, they heat and rarefy the blood; a quality not promising benefit where an hæmorrhage is to be stopped or checked.

Fluor albus is a flux of a mucous light-coloured liquid through the vagina. I take it in a general way to be derived from these same vessels in the uterus, that yield red blood during the menstrual flux. Hence it weakens so much; the quantity excerned that way in a month, greatly exceeding what is thrown off in one menstruation: hence it so often hinders that flux, and of consequence prevents conception; and when it does not hinder menstruation, it disappears while that goes on. And this last circumstance affords one of the best foundations for distinguishing fluor albus from a venereal gonorrhœa.

This distemper, if of long standing, which it often is before relief is asked for, is frequently very obstinate and difficult to remove. Rhubarb purges, with calomel being premised, astringent alteratives, as terebinthines, chalybeates, &c. suffumigations with thus, olibanum, mastic, &c. astringent injections, and pessaries duly persisted in, are in practice found most beneficial.

The ovaria are not seldom affected with dropsy.



## LECTURE. XXVII.

*Of the male organs of generation; of the semen masculinum; and of generation.*

THE parts subservient to generation in men LECT.  
are those which separate and prepare the XXVII.  
semen virile; which retain it, when prepared; and  
which in the act of generation throw it into the  
uterus muliebris. These are the testes, with the  
vessels that bring blood into them; their excre-  
tories; the vesiculæ seminales; the prostatæ; the  
urethra, and the penis: of all which we shall treat  
in order.

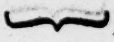
The testes or testicles are two oval bodies, pendulous without the abdomen, when the male is ripe for birth, and ever after; but resting within it in the younger foetus. They are defended from cold and other injuries by several membranes or coats. The most external is called the scrotum; which is made up of the epidermis, cutis, and immediately under the latter a thick cellular texture, closely adhering to it; but without muscular fibres, which many anatomists have assigned it. This covering is common to both testes. Next under it is what they call dartos. That coat envelops each testis singly, and by the junction of both together, where their sides are contiguous, make a septum or partition betwixt the two testes. It is likewise wholly cellular, without muscular fibres, and without fat. Under the dartos is the cremaster muscle; one to each testicle. They arise from the tendon of the obliquus descendens of the abdomen; get some fibres from the obliquus ascendens; and embracing the body of the testis all around, serve to raise it, and squeeze it in the act of generation. It is probable, that it is owing to the action of this muscle that the scrotum is gathered up into rugæ by cold; as neither it, nor the dartos, are furnished with

LECT. with muscular fibres, as we have said. Under this  
 XXVII. muscle is another coat of a looser cellular texture,  
 called the vaginalis : between which and the inner-  
 most coat of all is a loose space, in some measure as  
 between the heart and pericardium, where a watry  
 humor is contained. This is the seat of the hydrops  
 testis. The last and innermost coat is called the  
 albuginea, from it's white colour. It is a thick,  
 close strong membrane ; and is immediately conti-  
 guous to the kernel of the testis.

Thus sollicitously is the substance of the testes  
 defended from the injuries of the air, and other  
 external bodies, and kept warm, that, though they  
 are hung without the abdomen, they may be pre-  
 served in a fit condition to perform their office of  
 secretion.

To give the more clear idea of the structure of  
 the testes, we shall begin with the spermatic artery ;  
 tracing it from it's origin to it's distribution in the  
 substance of the glandular structure ; then proceed  
 to describe that structure ; and, lastly, prosecute the  
 excretory part, which conveys the secreted liquor  
 into the vesiculæ seminales.

The spermatic artery (one on each side) arises  
 most commonly from the aorta, under the origin of  
 the emulgent artery : and always in that neighbour-  
 hood. It is the smallest artery in the whole body  
 for the length it runs. From it's origin it descends,  
 giving off small branches here and there in it's  
 way ; accompanied with it's corresponding sperma-  
 tic vein, (which vein opens into the vena cava on  
 the right side, and on the left into the emulgent  
 vein) and with the vas deferens, of which more by  
 and by ; and along with these passes through the  
 ring of the abdominal muscles to the testis ; where,  
 giving off twigs to the coats of the testis, and to  
 the cremaster muscle, it's principal branches pene-  
 trate through the albuginea (the innermost coat)  
 by two plexuses ; one at the upper end, the other  
 at

at the lower end of the testis, into the secretory LECT. structure. And, as there is no red blood found in XXVII. the substance of the testis within the albuginea, , most certainly secretion begins immediately upon the entry of the arterial twigs into that substance.

The substance, or kernelly part of the testis, is of a white colour, and of a pretty firm texture; and though no injections, even of mercury, managed with the greatest art, could ever be made to pass through it's whole body, and make their way into it's outlets, yet reason and analogy oblige us to conclude that it is a continuation of the evanescent branches of the spermatic artery, rolled up together. It is divided into more than twenty portions or clusters, separated from one another by as many partitions, which are productions of the albuginea.

The organic structure of this substance is so intricate, and of so difficult investigation, that even the indefatigable WINSLOW has in some measure declined entering into a minute detail thereof. HALLER, besides using the common methods, by pouring mercury into the vas deferens, (which is the excretory canal of the testis) finds that each cluster, contained between two partitions, terminates in one duct; which ducts, above twenty in number, meeting together, form a kind of network adhering to the albuginea; every duct anastomosing with these contiguous to it. From this network arise ten or twelve other distinct ducts, which being separately bent and folded in a wonderful manner, make as many vasculous cones, and by their uniting constitute the head or beginning of the epididymis; and quickly by their conflux form one larger duct. This single duct variously bent and folded into serpentine windings, such as there is no instance of in any other part of the body, it's windings being fastened together by cellular texture, makes a roundish body on the upper and posterior part of the



LECT. the testicle, called epididymis, as it were an additional testicle; and at length terminates in the  vas deferens.

This is a cylindrical tube, firm and tough, about the thickness of a raven's quill; white like a nerve, with but a very small cavity. Mounting from it's origin, it passes through the ring of the abdominal muscles, along with the spermatic artery and vein, as hath been already said. The three are all enveloped in one common sheath or membrane, and called the spermatic chord or rope. When it hath got within the cavity of the abdomen, it separates from the spermatic vessels, sinks into the pelvis, and applying itself close and adhering to the bladder, and approaching nearer to it's fellow canal on the other side, they both open into the ducts of the two vesiculæ seminales respectively, by very acute angles, at the posterior part of the neck of the bladder.

But before we trace the rout of the semen farther, let us take a view of the vesiculæ seminales, and prostatae.

The former are two membranous bags or receptacles, one on each side, placed at the lower and posterior part of the neck of the bladder, into which the semen is received from the vas deferens we have been describing; and there deposited and accumulated, till it is thrown out by the urethra in the venereal act. They are each of them one uninterrupted cavity, shut at one end, and sending out a duct at the other, into which duct the vas deferens opens, as we have said, at a very acute angle. They are tied up into many folds by a cellular texture; which, when it is carefully dissected away, each vesicula appears like the portion of an intestine with several appendixes, like so many cæca hanging from it, the number and length of which is very various in different subjects. We are obliged to HALLER for this discovery. The external

térnal membrane appears to have something like muscular fibres in it. LECT. XXVII.

The prostatæ, as commonly called, though it is a single glandulous body, is a whitish solid mass about the bigness of a walnut, surrounding and closely embracing the beginning of the urethra. It separates a copious, white, thick, mild liquor; which liquor is thrown into the urethra in the act of generation, along with the semen, through ten or twelve orifices, by which the urethra and it communicate, where they touch one another.

We have already said, that the vas deferens joins the duct of the vesicula seminalis of it's respective side, opening into it by a very acute angle. The common canal, thus compounded of both, opens into the urethra by a very small aperture, one on each side, amidst the ten or twelve orifices, by which the prostatæ and urethra communicate. Hence in a dead body an injection thrown into the vas deferens makes it's way both into the vesicula seminalis of that side, and into the urethra, but rather more readily into the former than the latter; so that it appears that the semen in the course of being accumulated in the vesiculæ ascends by a retrograde angle; and in the act of generation, both the semen, contained in the vesiculæ and the liquor of the prostatæ, are expelled, mixed together, into the urethra. The powers that then expel them shall be considered afterwards. And it likewise appears that in the salacious, when the liquor of the vesiculæ is drained and exhausted by repeated coition, some semen may be derived immediately from the testis through the vas deferens, and thrown into the urethra, without touching at the vesiculæ at all.

From this anatomical detail we may observe the curious proceeding of nature in separating from the blood the liquidum genitale, or sperm in the male. The spermatic artery at it's origin is very small,  
and

LECT. and runs a long way, sending off branches to the  
XXVII. neighbouring parts as it proceeds, before it's ultimate twigs arrive at the secretory fabric within the tunica albuginea. Hence it is evident, that a very small quantity of blood comes to the substance of each testis, and with a very slow motion.

This substance of the testis, where the secretion is made, consisting of more than twenty glomera, or different parcels, divided by as many partitions, being, when summed together, immensely larger than the arterial tubules, of which they are a continuation; and the cavities of it's tubular texture being so extremely minute, that no injections can penetrate it; all these considerations plainly evince, that the secreted fluid, which in quantity is so little, is very minutely divided, and much acted upon during it's passage.

The ducts formed by the glomerated portions between each septum, twenty and upwards, meeting together in a kind of network, and inosculating one with another, make a farther elaboration of the secreted matter.

These ducts uniting afterwards into half as many new ones, which are separately bent and folded in a wonderful manner, contribute towards a farther change.

Then the last mentioned ducts unite to form the epididymis, a tube of one cavity only; which is a new circumstance, not without some physical effect. What was before divided into many canals being now mixed together in one, an opportunity is given for new cohesions to form, and the whole rendered more homogeneous.

And, lastly, the epididymis, a tube of one canal, as hath been said, being bent and folded into many serpentine convolutions, and continued to the vas deferens, which opens into the vesicula feminalis, through all this great length the semen must be much acted upon; the cavity of the tube being



being so very small; and, as probably there are L E C T. absorbing vessels in the vas deferens, it will be XXVII. somewhat thickened before it is deposited within the vesiculæ; but more so in those, where it totally stagnates till it is discharged by the exercise of venery.

All these successive changes in every part of this varied structure must be considerable in degree, as the motion of the semen can be but very slow in it's progress. It is propelled chiefly by the force of the circulation. And, if we consider the smallness of the spermatic artery at it's origin, and the branches it gives off before it's penetrating the albuginea, it will plainly appear, that the impetus propelling the secreted liquids through so intricate a fabric, as we have been describing, must necessarily be very languid. Perhaps the cremaster muscle, by it's insensible contractions, may contribute somewhat to urge on it's course.

In the testis the semen is comparatively thin and watery; somewhat inclining to a greenish yellow. In the vesiculæ feminales it is more viscid, and more yellow, no doubt upon the account of some of the watery parts being absorbed during it's stagnation there. It hath a particular heavy smell; different in different animals.

This liquor so slowly and solicitously secreted, elaborated and perfected, being injected into the uterus of the female in coition, is in all animals of the more perfect kind indispensibly requisite to fecundation; and either by it's matter, or agency, or both, makes the first rudiments of the embryo. The liquor of the prostatæ is not fruitful by itself; for, after the testes are cut off, that gland remains entire, and continues to secrete it's fluid. Eunuchs are capable of erection and coitus, and discharge the liquor of the prostatæ, but never impregnate. That liquor greatly increases the quantity thrown into the uterus in coition, the true semen being but  
a small

**LECT.** a small part, and thereby secures more effectually  
**XXVII.** the projection and reception of the foecundating ingredient; as small seeds are best sown, when mixed with a quantity of different matter. By it's viscosity, it adds a proper consistence to the semen; and by it's mildness, duly tempers it's rankness and acrimony; and, no doubt, answers other wise purposes to us unknown.

Give me leave to lay before you a reflexion that occurs to me upon this occasion. As the apparatus for secreting and perfecting the semen is so extremely operose and intricate, it would appear that nature in the affair of generation has one intention chiefly in view; to wit, that the semen, when perfected, shall retain as little as possible of the singular properties of the mass of blood peculiar to the individual; and by the structure and energy of the spermatic organs, become a substance, in which qualities, common to the whole species, are more predominant, than in any other animal liquid: in-somuch that the semen of different persons, though their particular masses of blood and constitutions be far from equally sound and healthy, may yet be nearly, and perhaps perfectly, equal in point of producing a sound and vital foetus. By this wise and bounteous provision, the child is less affected with the imperfections and distempers of it's male parent, than otherwise it would be. And upon the whole, one generation is as healthy as that which preceded it, supposing the manner of living to be the same in both. I readily own there are hereditary distempers; but without this sage precaution, is it not highly probable there would be many more? And do we not daily see puny valetudinary fathers, with sprightly strong children, where there are not the least grounds for suspecting the virtue and fidelity of the mother?

In the year 1677, Dr. HAMMIUS, a Dutch physician, first shewed the famous LEWENHOEK the animalcules

animalcules in *semine masculino* by the microscope. LECT. HAMMIUS left nothing in print upon the subject. XXVII. LEWENHOEK cultivated the discovery with great  assiduity; and communicated it, in a letter bearing date 1678, to our Royal Society, with a plate of the figure of these animalcula, as he found them in the sperm of dogs and rabbits. The fame of so extraordinary an appearance was quickly spread abroad, and engaged the attention of all who were curious in natural things. The semen of all kinds of animals was examined; and these moving little bodies, which were generally taken for animalcules, were found in every species. They are described and painted precisely of the shape of tadpoles, the young fry of frogs, with large round heads, and long small tails; and are found to move with a seemingly great velocity in the seminal liquid, like fishes swimming in water. See a plate of them in the last edition of CHESELDEN's Anatomy.

Before this discovery, the opinions concerning the nature and causes of generation were chiefly two. The first, which was held by the ancients, supposed a prolific semen, both in the male and the female, out of which, mixed together in the uterus of the female by coition, the embryo is made, as out of unformed matter; resembling either the male or female parent, in proportion as the semen of the one or the other is predominant. The other opinion was chiefly established by the great HARVEY. According to him, the several parts of the embryo are, antecedently to coition and foecundation, delineated within the egg; and not made out of the semen masculinum as it's matter, but only animated by it's vivifying principle; which principle he thinks is so subtle, as to escape our senses. This notion he was led into by what he observed in the uterus of does killed soon after copulation; having never been able to find the semen of the male lodged there, though he opened



LECT. numbers of them in the course of his researches.

XXVII. ~~The vivifying principle he called *aura genitalis*.~~

These two opinions divided naturalists, before the discovery of the feminal animalcula, which laid the foundation for a third hypothesis concerning generation, that hath continued almost universally to prevail, till very lately, that it hath been closely canvassed by great men, more enlightened with the knowledge of the animal structure, and more acquainted with the course of universal nature, than their predecessors could well be. This hypothesis lays down the following doctrine; to wit, that one animalcule *in semine masculino* is the very embryo itself; which either in the uterus, one of the tubæ Fallopiæ, or the ovarium, meeting with one ovum, torn off the ovarium *in coitu*, enters into it's cavity, and grows to it by the umbilical cord; there receiving nourishment, growth, and perfection, till it is ripe for birth.

This system was not a little promoted by the accurate observations of MALPIGHIIUS, concerning the formation and growth of the chick within the egg during it's incubation; by which there appears a remarkable analogy or similitude between the first rudiments of the chick, and the feminal animalcule.

Great hath been the controversy concerning this matter; and a great variety of arguments have been urged for and against the animalcular system; which the intended brevity of our lectures will not permit the discussion of. HALLER, in his Commentaries on BOERHAAVE's Institutions, hath exhibited a comprehensive summary of what hath been urged on both sides of the question. And I the more willingly decline being prolix on this head, that I find the ablest physiologists now-a-days are convinced we are still in the dark with respect to the intimate nature and efficient causes of generation. LINNÆUS, perhaps the greatest naturalist that hath hitherto

hitherto appeared, will not allow these moving LECT.  
moleculæ in the semen to be true animalcula; XXVII.  
though he examined them by the solar microscope. ~

HALLER inclines to believe them microscopical insects, peculiar guests of the animal sperm, which never grow bigger. But however that be, it may be reasonably concluded that they are, in some respect or other, subservient to the purposes of fœcundation, from their being found in the male genital liquids of every species of animals hitherto examined; and in no other animal juices.

*X and even  
indispensably  
necessary to  
= want*

Having treated of the parts, which prepare and retain the semen, and of the nature and properties of that liquid, we proceed to consider the remaining organs concerned in generation; those which transmit it to the uterus muliebris; to wit, the penis and urethra.

The penis consists of it's two corpora spongiosa, or cavernosa; part of the urethra; the glans, or nut at it's extremity, and it's integuments.

It's integuments are first the cuticula and cutis; which being folded back, and adhering round the root of the glands, forms the præputium; in the inside of which there are small glandular folliculi, which separate an oily substance, serving to make the præputium slip over the glands, and hinder them from growing together. This substance, by long stagnation, grows rancid and fetid, and forms white flakes. In hot countries it is more apt to corrupt and create inconveniencies, than in temperate climates. This seems to have introduced circumcision, which was very early practised all over the East; and was made a part of the Jewish religion. It is performed by cutting off the præputium quite round, close by the root of the glans.

Under this common integument, the penis hath a proper coat covering all it's body; from the glans,

**L E C T.** exclusive, backwards. It is of a tough tendinous  
**XXVII.** texture.

The two corpora spongiosa, which during erection make the chief bulk of the penis, arise from the os pubis on each side, and are continued to the root of the glans. They are so called, because they are porous like sponge, and capable of being enlarged by a fluid penetrating their substance; blood in the living animal during erection, or the injection of mercury; or inflation of air in the dead subject.

The urethra is a continuation of the neck of the bladder, and runs in a furrow between the two corpora spongiosa penis to the extremity of the glans. It's whole length, without the erection of the penis, is about twelve or thirteen inches: it's thickness about that of a goose quill. It consists of two thick strong membranes, with a spongy texture between them. It's beginning is surrounded and covered by the prostatae, as hath been said; at it's emergence from which gland it becomes thicker and wider for the length of an inch, which thick part is called it's bulb, from the resemblance it bears to a bulbous root. It's inner membrane is pierced with many holes here and there, through which, from a glandular apparatus in the spongy substance of the urethra, a mucilaginous liquor is furnished; serving to defend it against the acrimony of the urine. Besides these orifices, which some authors call lacunae, COWPER, in a particular treatise, hath described and beautifully delineated three glands, two near the bulb of the urethra, one on each side, about the bigness of a pea, each of which sends off a long duct opening into the urethra; and a third single one, less than the other two, at it's bend under the os pubis; which sends off two ducts opening likewise into that canal. The first two are often found; but sometimes wanting, or very small. The third is but seldom met with by the best anatomists.



tomists. Where they exist, they probably serve for the same use as the other lacunæ. LECT.  
XXVII.

These glandular outlets are the seat of gonorrhœa in men. Women, though their urethra is shorter and wider, are not without the same kind of lacunæ, serving for the same use, and liable to the same infection.

The glans, though in appearance a part of the body of the penis, is in reality a continuation of the spongy substance of the urethra, reflected over it's extremity, and expanded in the form we see. It is covered over with a thin epidermis; under which there are numerous nervous papillæ, which render it extremely sensible.

The penis is plentifully supplied with blood vessels from the iliacs, both external and internal. It's nerves come from the lumbar and sacri.

Having briefly described the genital organs of both sexes, we proceed to consider the act of generation itself. In the male an erection of the penis is requisite. This is effected by arterial blood poured in sufficient quantity into the cells of the corpora cavernosa, or spongiosa of the penis, and there arrested; whereby they are distended in every dimension, and the penis is rendered longer, thicker, and rigid. That erection is brought about by true blood, and not spirit or flatulency filling and distending the spongy cells, is evinced by SWAMMERDAM's experiment. He tied the turgid penis of a dog in coitu, and cutting it off between the ligature and it's root, he found that a large quantity of blood flowed out of the corpora spongiosa between the ligature and the glans, when wounded. His rival and antagonist DE GRAEF repeated the same experiment with the like success.

But the difficulty lies in accounting for the blood's being accumulated and arrested in these spongy parts of the penis, so as to create an erection, why it returns not by the veins as readily as it flows in

*glans*

LECT. by the arteries. Till of late the generality of anatomists ascribed that effect to a pair of muscles, which, from their imagined office, they termed *erectores penis*. These muscles arise, one on each side, from the os pubis, between it's tubercle, and the origin of the corpora spongiosa of the penis; and are inserted each into one of these of it's side. When they act conjunctly, according to them, they pull the penis upwards, and compress the veins that run upon it's back; thus hindering the venous blood from returning, and forcing an effusion of it from the arteries into the spongy cells. But even if it should be granted that these muscles, when acting, turn the penis upwards, which may be called in question, that action does not seem adequate to the effect in dispute, because many animals want these muscles; and, as Dr. WHYTT acutely observes, an erection cannot be procured, *ad libitum*, by turning up the penis towards the os pubis. There must be then some more subtle cause, which is as yet obscure. HALLER, and with him DUVERNOY, thinks that small nervous filaments may, like sphincters or ligatures, embrace and compress the capillary veins; and by hindering the reflux of blood, fill the spongy cells.

Dr. WHYTT is of opinion it may be ascribed to an increased oscillatory motion in the capillary arteries that open into them, occasioned by the titillation of the semen, or lascivious ideas, by which means more blood is thrown into the spongy caverns than can in the same time return by the veins. But however that be, nothing needs hinder us from believing that, when erection is fairly set on foot, the *erectores* muscles may contribute to keep it up, and maintain a proper direction of the penis, somewhat between perpendicular and transverse, requisite to make it's way rightly into the vagina, and throw the semen into the uterus.

The erected penis being introduced into the vagina, by the friction of the glands against it's rugæ, and by the heat of venereal imagination, becomes still more turgid. At length the glans itself becomes rigid and erected, which it was not at first: for being a continuation of the spongy part of the urethra, and not of the spongy bodies of the penis, it, together with the urethra, hath a distinct erection of it's own; to effect which a stronger cause is required, and therefore it comes later. Quickly after the erection of the urethra and glans is completed, follows an expulsion of semen, together with the liquor of the prostatae; the muscles, which immediately press upon and evacuate the vesiculæ seminales and the prostatae, being thrown into convulsive contractions, in the same manner as tickling of the nose occasions sneezing. These muscles are the levatores ani, which arising (one on each side) broad from the os pubis, and os ilium, and growing narrower as they descend, and encompassing and embracing the vesiculæ seminales and the prostatae, at length are inserted in the sphincter ani. They, besides their office of raising the extremity of the rectum, of which we have treated before, while we were considering the expulsion of the faeces, likewise must, by their sudden contraction, forcibly squeeze the vesiculæ seminales and the prostatae against the neck of the bladder, and propel the semen and liquor of the prostatae, by the orifices we have already described, into the urethra, with a sudden explosive impetus. But as the urethra is long, is bending, and grows wider at it's bulb, this first impetus carries the propelled liquor no farther than the bulb; where, as soon as it arrives, the muscles called acceleratores urinæ are irritated into sudden action, and expel the compounded liquor with a considerable force through the remaining part of the urethra into the uterus. These acceleratores muscles arising on each side from



Let the corpora spongiosa penis, and closely embracing  
 XXVII. the bulb of the urethra, meet together, and are  
 inserted in it's middle, reckoning lengthwise; and  
 therefore suddenly contracting must, by compress-  
 ing the bulb, forcibly urge on the seminal liquor;  
 pretty nearly in the same manner, as the ventricles  
 of the heart propel the blood transmitted to them  
 by the auricles.

This is what happens in the venereal act on the  
 man's side; let us consider what passes on that of  
 the female. The adult woman, endowed with a  
 like natural inclination to propagate the species,  
 when she receives the penis virilis into the vagina,  
 hath all the parts concerned in generation heated  
 and turgid with the afflux of blood and spirits;  
 and by the exquisite sensibility of the vagina, which  
 is furnished with nervous papillæ, at length arrives  
 at the *summa voluptas*; in which point of time, if  
 the coition is fruitful, the tubæ Fallopianæ embrace  
 the ovaria with their fimbriæ, and pull off one or  
 more ovula, determining them into their cavity;  
 where being received, they are, by the muscular  
 structure of the tubæ, sooner or later protruded into  
 the uterus, through their orifices opening into it,  
 which no doubt in the live female, especially upon  
 such occasions, is much more patent than in a  
 dead subject. An ovum impregnated by the se-  
 men masculinum, in coitu, becomes the nidus in  
 which the embryo begins to enjoy animal life,  
 grows, and is nourished till it be ripe for birth.

That the tubæ Fallopianæ grasp the ovaria in  
 coitu, is proved by undoubted observation. DE  
 GRAEF found it so in many rabbits, which he  
 killed and opened immediately after coition. And  
 RHUYSCH had the fortune to meet with one case  
 of the same kind in a woman. Foetuses have been  
 found in the Fallopian tube; numerous instances of  
 which are cited from original authors by HALLER,  
 in his Notes on BOERHAAVE's Institutions.

The

The principal original authors on the parts of LECT. generation are SWAMMERDAM, and DE GRAEF. XXVII. HALLER hath pushed his enquiries further; and more successfully unravelled the intimate structure of the testes and vesiculæ feminales. To whose works may be added the very elaborate and accurate *Theses* of Dr. ALEXANDER MONRO junior.

Numberless authors have wrote on generation. The great HARVEY's Treatise is in high esteem at this day, as it contains many valuable observations, though his opinion concerning the manner of foecundation is not followed. The student will find the substance of what later authors have discovered concerning this subject collected by HALLER in the above cited book.

## LECTURE XXVIII.

*Of conception: the corpora lutea: the ovum or egg:  
the embryo: the ripe fetus; and birth.*

CONCEPTION is the immediate effect of a LECT. fruitful coition, on the woman's side; and XXVIII. may be defined, that change brought on the egg, by which a living embryo, or unripe animal, is begun to be formed within it. There are disputes concerning the place, or seat of conception; whether it is in the ovarium itself, in the tubæ, or solely in the uterus. It is perhaps impossible perfectly to clear up this matter, upon the account of the minuteness of the egg, and for want of conclusive observations: but as true semen masculinum hath been found in the tubæ, in animals killed immediately after coition; and RHUYSCH met with an instance of it in the human species; as it is certain that in coitu the tubæ grasp the ovarium; as foetuses have been often found within the tubæ, and sometimes within the ovarium; and as in birds there is no uterus, properly to be called so, the oviduct

LECT. XXVIII. oviduct answering to a tuba; upon all these accounts it is highly probable, that conception is set on foot either while the tuba is embracing the ovarium, or soon after, before the ovum is propelled into the uterus.

+ in a common way  
Immediately upon conception, or very soon after, but not before, a new appearance presents itself in the ovaria, to wit, the *corpora lutea*. I have said corpora in the plural number, as authors commonly do, but you are to observe, that in the human species, where there is but one embryo, there is but one of these; their number constantly answering that of the foetuses the mother is pregnant with. They are roundish bodies, of a structure seemingly glandular, yellow like the yolk of an egg, and contained within that, which is commonly called the egg; to wit, a vesicle filled with a limpid coagulable fluid; such as are found in the ovaria of grown virgins. Each of these corpora lutea, if there are more than one, after their first appearance, grow larger, while that which is commonly called the egg decays and diminishes. They continue all the time of pregnancy, and for a small space after delivery, and then shrink and vanish.

That these corpora lutea never appear without previous conception, HALLER positively affirms, in his Reflexions on BUFFON's System of generation. "Women, says he, who die without having once conceived, have never had these glandular bodies," meaning the corpora lutea. And in another place he adds, "I have opened hundreds of female subjects, both young and old, unprejudiced, and without views of establishing any new opinion; and I believe I have not been able to find the corpora lutea above ten times; and that was always either in impregnated bodies, or soon after delivery." The same is asserted, upon the faith of experiments, by BOHNIUS, DE GRAEF, and



and others. It is true indeed that HALLER, before LECT. the publication of the above quoted reflections, XXVIII. upon the authority of MALPIGHIIUS, VALISNERI, and other great men, had believed and taught, that the corpora lutea appeared before conception; but afterwards being convinced of the contrary, by a series of his own observations, he, with his usual love of truth, and greatness of mind, hesitated not to retract his error.

It is now the opinion of the most able physiologists, that the true ovum, within which the embryo is lodged, is not that which is commonly reckoned so, to wit, one of those vesicles full of limpid juice, which are found in the ovaria, but a much less one, contained within the cavity of the corpus luteum in it's very primordia; which ovum, after conception, leaving the corpus luteum behind it, passes through the tubæ into the uterus, and there grows and ripens. And this opinion is supported by very feasible arguments. First, by the analogy of the eggs of birds, in which the rudiments of the chick is inclosed within the yolk. Secondly, by the corpora lutea never appearing till after conception. Thirdly, by their number, in animals that bring forth more than one foetus at a birth, constantly answering that of the young ones they are pregnant with. And lastly, by the true impregnated eggs, found within the tubæ, being of a much less size than the vesicles in the ovarium. At the same time it must be owned, that a true ovum, with the embryo in it, was never found within the corpus luteum, by any, whose testimony can be depended upon. LITTRE indeed relates such an observation; but the fidelity of that anatomist is not a little suspected by the best judges, in more instances than one.

The uterus, after conception, remains shut in brute animals. This is certain; and it is highly probable the case would be the same in the human species,

**L E C T.** species, if coition were not practised after it, which **XXVIII.** brutes never do; and hence prostitutes seldom conceive, the os uteri being so often violently opened, gives the ovum an opportunity of slipping out through the vagina, before it is sufficiently fastened to the uterus.

From conception, until the egg hath been some five or six days in the uterus, it is almost impossible to describe the changes it undergoes; upon the account of it's minuteness, and for want of observations. After that time we may speak of the matter with more certainty. The egg is then a round pellucid globule, of only one membrane, containing the embryo; which hath a very large head; a small body, and no legs or arms, swimming in a large quantity of a pellucid liquor, which is coagulable by fire and alcohol. The embryo hath then a large, flat umbilicus, by which it adheres to the obtuse extremity of the egg.

This proper membrane of the egg, called amnion, by degrees sends off all around it's surface small flocculent vessels, whereby it grows to those vessels in the inner surface of the uterus, by which the menses were wont to flow before pregnancy; and likewise to the absorbent vessels of the uterus. These flocculent vessels of the egg, thus inosculating with the vessels of the uterus, form a communication between the egg and the mother; by which the egg and foetus are nourished and grow, and the water it swims in is supplied and increased. The implantation of these vessels, though in some measure all around the egg, yet is thickest at the fundus uteri, that part of it between the openings of the two tubæ Fallopianæ. By degrees these flocculent vessels, round the greatest and inferior part of the egg, towards it's sharp end, cease to grow, and are as it were transformed, or degenerate into a second membrane, called chorion; while those at the upper and blunt end keep increasing in their diam-

diameters, and at length form a round vascular LECT. substance called placenta, from it's resemblance to XXVIII. a cake. In the mean time the foetus grows, and the egg containing it, but the foetus in growing acquires a greater proportion of magnitude to the egg, and the water contained in it, than it had at first, though they are all enlarged. The uterus being gradually distended, it's vessels of all kinds are enlarged, as well as those of the foetus and the egg: till at length the vessels of the placenta, which at first admitted lymph or serum only, now admit red blood.

The trajection of red blood from the uterus to the placenta, and from the placenta to the uterus, hath been doubted of, upon the account of the great difficulty of making the thinnest injections pass either way; whereas, in other places in the human body, millions of vessels may be filled with a red injection, which naturally received not red blood. This is indeed a reasonable objection, and therefore deserves attentive notice.

In the first place it is certain, that there is red blood in every part of the placenta, and in every part of the uterus contiguous to the placenta. The whole body of the placenta may be filled by injecting a coloured liquid, either through one of the umbilical arteries, or through the umbilical vein. And upon the easiest delivery, when the placenta is brought away, there is always (in a common way) more or less hæmorrhage. But how does it appear that red blood passes, as such, from the vessels of the uterus to those of the foetus, and from the foetus to the uterus? I think well vouched histories, as they appear to be, of the foetus being exhausted of blood by an hæmorrhage from the mother, and the mother's being exhausted of blood, and even killed by an hæmorrhage from the *funis umbilicalis*, before the placenta was separated from the uterus, render the affirmative highly probable, to say the least of the matter.

Though



**LECT. XXVIII.** Though it be difficult to throw liquids from the vessels of the uterus into the placenta, it is not impossible. **VIEUSSENS, COWPER, and HALLER,** affirm they have made mercury pass that way. And the latter mentions injections even of wax and tallow to have been attended with success. But besides, if it be difficult to fill the veins in any part of the body, by injecting a fluid through the arteries, suppose in a ripe foetus, will it thence follow, that red blood, as such, doth not flow in the foetus from evanescent arteries into the correspondent beginnings of veins?

I therefore stick not to believe that red blood, as such, is brought from the mother to the foetus, and transmitted from the foetus to the mother, as it were in a circle; and am going to explain the particular manner of this intercourse: but must first describe the umbilical rope or cord, and the distribution of it's vessels.

The umbilical rope consists of two umbilical arteries, and one vein, and the urachus; all covered over with a pretty thick membrane, approaching to the consistence of cartilage; which membrane is a production of the amnion. It proceeds from the umbilicus or navel of the embryo; and is implanted in the placenta, where it's blood-vessels, arterial and venous, are branched out, and compose it's substance. It resembles a rope, not only by it's being long and round, but by the contortion of it's larger vessels.

The two umbilical arteries arise from the internal iliacs of the embryo, one on each side; they are of a considerable bigness, and are ramified all over the placenta, as hath been said; their branches inosculate together in it's substance; and are lost by their evanescent extremities in that part of the chorion, which is interposed between the placenta and the uterus. For the chorion surrounds the whole amnion, including likewise the placenta.

The

The origin of the umbilical vein is from small LECT. venous tubuli, arising from the chorion, where the XXVIII. evanescent twigs of the arteries are lost; which uniting, and forming larger and larger branches, at length run all into one very large trunk, bigger than both the arteries put together; which trunk, entering the umbilicus of the embryo, goes to the liver, and opens into the sinus of the vena portarum; from which sinus there arises in the foetus a particular large trunk, called the venous duct, opening directly into the vena cava, and transmitting it's blood to the heart. This venous duct is obliterated in the born animal. It is probable, that the greatest part of the venous blood in the foetus is returned to the heart this way; the venous duct being so large, and it's opening into the cava so patent. The rest of it being blended with the blood in the sinus of the vena portarum, passes by a more round about course through the substance of the liver, conveyed by the small ramifications of that vein, and terminating ultimately in the cava.

From this description it may appear, that the uterine arteries in the mother bring arterial blood to the organ of the placenta in the egg; which being taken up by the beginnings of the veins of the placenta, is transmitted to the foetus, through the umbilical vein, into the vena, portarum; and from thence into the cava and heart. And the two umbilical arteries in the foetus being continued from the aorta, carry their blood to the placenta; which blood, at the adhesion of the placenta to the uterus, is taken up by the beginnings of the uterine veins, and transmitted to the cava and heart of the mother.

This is the manner in which the blood flows from the mother to the foetus, and from the foetus to the mother; what was arterial in the one becoming venous in the other interchangeably. But the foetus hath some peculiarities in it's own proper circulation,

LECT. circulation, by which it differs from the born animal, which we proceed to describe.

XXVIII.

As it cannot breathe within the womb, because it swims in the liquor of the amnion, inclosed in membranes, it's lungs cannot be alternately expanded and constricted, ~~as~~ these of a born animal; and therefore the trajection of blood through them cannot be so expedite and free in utero, as after birth. But all it's blood within the channel of it's proper circulation must pass through the heart in an uninterrupted rout; therefore there is a contrivance, by which a great part of the blood of the foetus passes from the one division of the heart into the other, without touching at the lungs; to wit, there is a wide open passage from the right auricle to the left, called foramen ovale, as being a hole, not a canal; and a communication between the pulmonary artery and the aorta, called ductus arteriosus, which is a canal of some length. By this contrivance a great quantity of the venous blood of the foetus passes from the right auricle and sinus of the heart directly into the left one; and a suitable quantity of arterial blood, when thrown into the pulmonary artery from the right ventricle, flows into the aorta. In the mean time no more blood is transmitted through the lungs, than their collapsed state will admit of, and what is sufficient for their nourishment and growth, and to prevent their vessels, and cellular cavities, from growing together.

There have been great disputes concerning the use of these two passages peculiar to the foetus: particularly between MERY a Paris anatomist, and VERHEYN. The latter maintained the opinion we have delivered; which now universally prevails.

The manner of the nutrition of the foetus hath likewise been matter of much controversy. Some have maintained, that it is nourished solely by blood supplied by the vessels of the umbilical cord; others are of opinion, that it is nourished both by that blood

+ like



blood, and the liquor of the amnion, in which it LECT. XXVIII. swims; as a fluid like that liquor in every property is found in the gullet, stomach, and small intestines of the foetus; and as a large quantity of faecal matter, like opium in colour and consistence, and therefore called meconium, is found in the thick intestines. From which appearances they concluded that the liquor of the amnion hath a communication with, and is admitted into, the primæ viæ of the foetus, and there in some measure concocted, when the stomach and intestines are so far advanced in their structure and growth, as to exercise their functions; the finer and more fluid parts being propelled into the lacteals, while the more gross remain behind; and form the meconium, we have just now mentioned. And some few have gone so far as to impute the whole growth and nourishment of the foetus to this liquor solely, exclusive of the blood supplied by the umbilical cord.

I believe it will require few arguments to prove, that the foetus must receive at least part of it's nourishment from the blood sent from the mother, as our limbs are nourished by arterial blood, or juices derived from it, distributed to them out of the general mass. To maintain the contrary position is extravagant. And therefore the dispute turns upon this question, whether the liquor of the amnion hath or hath not likewise a share in the nutrition of the foetus?

I think I have, in a paper lately published in the Transactions of the Royal Society, proved incontrovertibly the affirmative side of this question: and that by prosecuting an observation, which casually fell in my way. The substance of the argument is this; the meconium of a ripe calf is constantly found full of tough strong hairs, of the same colour with those of it's skin; whereas, in an unripe foetus of the same species, before hairs are formed,

LECT. or before they are of so long standing, as to be capable of being loosened by maceration in the liquor of the amnion, none are to be met with in it's meconium. From which it clearly follows, that the liquor of the amnion finds a way into the stomach and intestines of the foetus; otherwise, how could hairs, loosened from it's skin by maceration in the liquor of the amnion, come into the thick guts, and there get entangled in the meconium? Where hairs pass, fluids may, and must pass with greater ease. And since the liquor of the amnion is not destitute of the characteristics of a nutritive fluid, being, as hath been before observed, coagulable by fire and alcohol, we may conclude safely, that the foetus is nourished thereby in a considerable measure, especially in the last months of gestation, when the umbilical arteries bear a lesser proportion to the body of the foetus than before, and the organs of chylickation are more completely formed. This single consideration seems sufficient to supersede all further debates on the subject.

We mentioned the urachus, as constituting part of the umbilical cord. It is a small production of the urinary bladder of the foetus, which in brutes is pervious the whole length of the umbilical cord, and opens into a peculiar, capacious, membranous bag, between the amnion and chorion, called allantois, containing the urine of the foetus, which in a calf amounts to a very considerable quantity. In the human foetus, the urachus is pervious but a very short way, and there is no liquor found between the chorion and the amnion. Upon which account the existence of this third membrane, the allantois, in the human foetus, is almost universally denied by the best anatomists. But some have asserted it, and even preparations of it have been shewn; but they have not been thought satisfactory. In the surreptitious treatise of comparative anatomy,

anatomy, ascribed to a celebrated professor, the arguments on both sides are clearly and fairly stated. LECT. XXVIII.

The author, who searched for it with the utmost care in three different subjects along with another very accurate anatomist, informs us he never could find it; but modestly leaves the question of it's existence undecided. So that the probability seems to lie far on the negative side.

As the bladder in the human foetus is never found full, or even near full, of urine, it would appear that nature hath spared the pregnant female the additional burthen of a full allantois, which would be much more incommodious in our species, than in quadrupeds, by contriving such a structure, as brings about a more sparing secretion of urine: and I meet with a conjecture concerning this matter in a late collection of observations by RAMSPEC, professor at Basle in Switzerland, which to me appears ingenious; to wit, that in brutes the umbilical arteries are much less than in the human species; hence the human foetus sends it's blood more expeditiously back to the mother, and therefore there is less time allowed for the secretion of urine.

We observed that the foetus, when very small, appears with a large head, and a small body, without legs and arms. The head is first perfected; the thorax or breast next; then the abdomen; and last of all the extremities.

As the foetus and egg grow in bulk, the uterus is distended; but retains the same, or nearly the same, absolute thickness; the blood-vessels, which in it's natural contracted state lay folded and rolled together like threads in a clue, being streightened out, now receive blood more freely than before, and become of greater diameters. So that what the uterus loses of thickness by distension, in it's membranous or cellular parts, it gains by the enlargement of it's vessels.



**L E C T. XXVII.** As it is gradually more and more distended, it's fundus rises more and more out of the pelvis up into the abdomen towards the colon and stomach, and being stretched in every dimension, creates that bulk we see in pregnancy. It's mouth indeed doth not appear quite shut; but by being besmeared by the mucus of the sinuses there, and perhaps by that of the vesicles that are seen in it's cervix, it is, or seems to be, defended from the air.

The natural situation of the foetus in utero for the last months of gestation (for before that time it is uncertain and various) is as it were sitting; with it's head and neck bent downwards and forwards; it's knees drawn up to it's cheeks; it's heels lying back towards it's hips; and it's hands hanging down, and as embracing it's knees. But there is a great variety of postures of the foetus, both before and at the time of delivery, as is shewn in midwifery.

When the foetus is now perfected and ripe for birth, which in the human species is commonly reckoned to happen at the end of the ninth calendar month from conception; but I believe may be more accurately determined, by fixing it at the end of the tenth lunar month, according to VIRGIL, who was the best naturalist of his time;

*Matri longa decem tulerunt fastidia menses.*

I say, when the foetus is now ripe for birth, it's posture changes, if it hath not been changed some considerable time before; it's head tumbling down towards the os uteri, with it's face towards the os sacrum; in which position it creates, by compressing the intestinum rectum of the mother, the same sensation to her, as if there was a great quantity of faeces there, and of consequence brings on tenesmus; and the posture, being likewise uneasy to the foetus itself,

itself, makes it winch and kick; this increases the L E C T. uneasiness of the mother; which, when it becomes XXVIII. excessive, the uterus is stimulated to exert what muscular force it hath, and endeavours to rid itself of the painful burthen. But at the same time the strong auxiliary force of the abdominal muscles is called in; whereby the uterus is violently pressed upon, the force of the pressure being determined downwards, as there is a passage that way, and no other; part of the chorion and amnion, with the contained water, is pushed towards the os uteri, there forming a cone, and serving to dilate it. The convulsive contractions of the uterus itself, and the abdominal muscles, becoming extreme, the membranes, with the contained water, are farther urged and pushed. At length the membranes burst, and the waters run out; this effusion lubricates the os uteri and vagina; and by repeated painful throes, fewer or more according to their violence, the head of the foetus makes it's way through the moistened passage; and the body easily follows, it's shoulders being little, if at all, thicker or broader than the head, with part of the umbilical cord: and there remain in the uterus the membranes, the placenta and the rest of the cord, which are called the secundines or afterbirth. These would soon follow in a general way, and be expelled by the efforts of nature; but commonly the placenta is loosened from the uterus by the midwife, and the afterbirth removed. Upon which a flooding, more or less, ensues; the vessels, by which the placenta adhered to the uterus, being torn and broken off.

When the afterbirth is brought away, the navel-string is tied by art, and cut off; it being found safer upon the whole to do so, than to leave it untied. Brutes are said to bite it off by instinct, and the wound soon heals. After the communication between the foetus and mother is cut off, the umbilical

LECT. XXVIII. umbilical vessels cease to be hollow tubes. The vein, having no blood to return by it, soon collapses, and it's walls grow together. But it remains in some measure useful, as a membranous ligament supporting the liver. The arteries in time shrink quite away, except the twigs they send off to the bladder, which still continue open.

The fœtus, as soon as it comes into the open air, breathes; and after it hath once breathed, though but a few turns, cannot subsist a moment without respiration, though it never breathed, or could breathe in the womb. And if it is excluded within it's membranes before they burst, swimming in it's liquor, it may subsist some hours separated from it's mother without respiration; but if the membranes are broke, and the waters let out, it is quickly suffocated, if not permitted to breathe. Anatomists and physiologists have been extremely puzzled to solve these difficulties, ever since the great HARVEY proposed them in their full strength. And I think they have not been solved in a satisfactory manner, till very lately by Dr. WHYTT, in his excellent essay on vital motions; from which I shall give you the substance of the solution.

And first, why doth the new born child breathe that never breathed, or could breathe before? What makes it immediately attempt the new action? To answer this it is sufficient to say, that as air alternately drawn into, and expelled out, of the lungs, and this to be repeated with a constancy, is in the born animal at least as necessary to the preservation of life as food and drink, it is as natural to a new born child to breathe, as soon as air can be admitted, as to eat when it is hungry. It hath organs to respire with, a faculty of using them, and air at hand. Before birth it could not breath, because air had not admission to it's lungs; and therefore the peculiar passages



passages for it's proper circulation were provided. LECT. XXVIII.  
But as it's blood was furnished by the mother, who herself breathed, it stood in no need of a proper respiration, while that communication subsisted.

But the fœtus may hold out some hours after it's separation from the uterus, without breathing, if it's membranes are entire, and the liquor of the amnion is not let out; whereas, if it hath once breathed, it cannot be deprived of respiration a single minute without being suffocated. How is this to be accounted for? Before it hath once breathed, the course of it's circulation continues the same it was when in the womb; that is, a small part only of the blood passes through the lungs; the bulk of it flowing from the right division of the heart, directly to the left, by the foramen ovale, and ductus arteriosus. And therefore it may go on in the same channel some hours after the separation of the whole fœtus from the uterus; and the fœtus continue alive, until it is either benumbed with cold; or perhaps perishes, for want of the effect, which the respiration of the mother had upon it's blood, while it remained in utero. But when it hath fully respired, though but for a few turns, the lungs having been expanded, it's blood must take a new route through the pulmonary artery and vein; which vessels will therefore be much enlarged over all their branches, in comparison to what they were before. If respiration is then hindered, the trajection of the blood through the lungs will be stopped; and the animal must perish by an accumulation of blood in the pulmonary vessels: though surely not quite so soon as a grown animal would perish in the like circumstances, because the private passages above mentioned are not as yet rendered intirely uselefs. New born animals are found to live longer in an exhausted

LECT.hausted receiver, than adult ones of the same  
XXVIII. species.

Immediately upon delivery, when both the foetus and afterbirth are excluded, the uterus, which before was so enormously distended, being now left at liberty, contracts itself gradually, but with considerable force. This contraction at first adds to the flooding, by propelling the blood already contained in it's dilated vessels into the cavity: but when the uterus becomes nearly as narrow as it was before impregnation, it's small arteries, instead of red blood, emit a thin, greenish fetid liquor, called lochia, in English cleansings. This flux continues some days, more or less, according to the habit of the person. It serves to keep the mother from fever, by the drain; and to hinder the uterus from being inflamed. And, when it stops too soon, bad symptoms ensue.

In the mean time, great care of the woman in childbed ought to be taken. Warmth, and a temperate humid diet, ought to be directed; and rest and moderate sweating encouraged. Catching of cold is here extremely dangerous: many lives have been lost thereby. Every thing that hurries the spirits ought to be carefully avoided, as too early sitting up, or too long; and too much noise or discourse, &c. And in general, animal food, and fermented liquors, should be allowed very sparingly.

About two or three days after delivery, when now the uterus is restored to it's natural smallness, and the lochia either are quite stopped, or flow sparingly, the breasts are much distended and tumefied; the course of the circulation, which, during pregnancy, was directed in an extraordinary degree downwards to the uterus and the foetus, now being turned more upwards.  
And

And as the breasts are placed without the thorax, LECT. XXVIII. with nothing to resist the extraordinary influx, but the common integuments and fat, their vessels of all kinds, both sanguiferous and secretory, become enlarged. A fever, and often a violent one, is raised in this juncture, which is an instrument in the hands of nature to open the glandular texture of the breasts, and force a secretion where there was none, or next to none before. At length a copious serous liquid flows into the mammary tubuli, to be sucked by the child. This first secreted liquor is called in Latin colostrum; in English beestings. It is of a scouring and loosening nature, and serves to expel the excrementitious meconium in the new born child. The colostrum is followed by milk, which is chyle that hath passed once, or but seldom, through the heart and lungs; whose properties are well known. This aliment nature hath provided for all new born viviparous animals of the more perfect kind, to support them, till they be able to shift for themselves; and till their teeth grow, by which they may tear, cut and comminute the food, fit to nourish their respective species.

We shall, before we conclude, take notice of some more of the principal differences betwixt the foetus and grown animal.

And first it abounds more with vessels and fluids; and hath less of the unorganised solid parts. After birth, as the child grows daily bigger and stronger, the absolute force of the heart increases, and the blood vessels are gradually enlarged: hence an increased force of circulation is produced; which, together with the action of the muscles, obliterates many small vessels, by pressing their sides together, and so changing them into solid fibres. The tendinous



LECT. parts of muscles increase in proportion to their  
 XXVIII. fleshy bellies. Membranes are hardened into cartilages, and into bones; ossification beginning in different parts at one and the same time, and propagating from points, as centers, towards their circumference. The teeth lurk under the gums in a gelatinous form, without roots; and there is a twofold row of them, one under another. The uppermost cut through the gums during infancy; and when these are shed, the other row succeeds. The fluids of a foetus are in general thinner than in the grown animal. The fat is gelatinous, and not pure adeps or tallow.

*Softness & distensibility*  
 The glandular viscera, excepting those concerned in generation, are all bigger in proportion to the other parts; as the brain, liver, kidneys, capsulae atrabiles, thymus, mesenteric glands, &c. no doubt upon the account of the softness and distensibility of the membranes that envelop them; which afterwards growing firmer, hinder them from increasing in bulk so fast. The kidneys in particular, besides their being large, are, in a very young foetus, divided into different glandular portions, as beasts kidneys always continue to be.

The lungs of a foetus, which hath never respired, are collapsed, of a livid colour, and sink in water. But after the foetus hath breathed, as the air drawn in cannot get all out of them, they become of a more florid colour, and swim in water. And therefore in trials for child murder, great attention is given to the sinking or swimming of the lungs, that a judgment may be formed whether the child was born alive or dead. But let it be considered, that though the child hath been born dead, and therefore never breathed, yet if it is kept long, and it's lungs begin  
 to

to putrefy, they will become specifically lighter, L E C T. and therefore may float. So that regard ought XXVIII. to be had to the freshness of the lungs, as well as to their specific gravity.

Before birth, and at the time of birth, the external passage of the ear is closed up with a thin membrane, which is a continuation of the epidermis. This membrane soon shrinks, and vanishes. In the unripe foetus the pupil is covered with a vascular pellicle, a continuation of the iris, which in the ripe foetus is quite gone. It is probable that the blindness of puppies for some days after they are littered, and of other quadruped foetuses, is owing to this pellicle remaining longer than in the human species.

Lastly, by the destruction of the umbilical vessels, more blood must be supplied to the lower extremities, in proportion to the other parts, than was before. The umbilical arteries arise, as we have said, from the iliacs: and in the human foetus are large. These being shrunk, much more blood must be sent by the other branches of the iliacs to the hips, thighs, legs, and feet, than in the foetus. Hence in a foetus the lower extremities are short; and in the born child grow daily longer and longer, in proportion to the head and trunk.

This is well known to painters, who regulate their proportions accordingly, in drawing children of different ages.

Amongst the older anatomists, who have treated professedly on the foetus, ARANTIUS is the first that merits <sup>particular</sup> commendation. Soon after him FABRICIUS AB AQUAPENDENTE handles this subject at large; and illustrates it with numerous and pompous figures. The immortal HARVEY's book *De Generatione Animalium*, no naturalist should be without. Late writers have made great additions

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**L**ECT.ions and improvements. **R**HUYSCH and **K**ER-  
**XXVIII**KRINGIUS deserve particular attention. **M**ONRO,  
 in his Osteology, hath many things relating to the  
 bones of the foetus. **N**ESBIT, in his Osteogeny, im-  
 proves upon **K**ERKRINGIUS. **A**LBINUS, in his  
 work entitled *Icones Ossium Foetus*, hath, besides  
 his valuable text, exhibited a specimen of incre-  
 dible diligence, and a marvellous beauty and  
 exactness in his figures. And **D**r. **T**REW hath  
 treated most accurately and fully on the differences  
 betwixt the human foetus in utero, and the born  
 man.

**F I N I S .**



**MVSEVM  
 BRITAN  
 NICVM**



